THE GLASS INDUSTRY

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BALL BROTHERS COMPANY TRAINING PROGRAM

By VIRGIL J. COX

Training Director, Ball Brothers Company

Pre-training for supervisory, executive and technical employees was included in the Ball Brothers Company's program in 1939. At that time the program was limited to training in two or three departments of the factory organization, and the men accepted for training were university graduates with degrees in engineering.

During the war years when so many of the younger men left industry or college to enter military service, the training program was discontinued until 1945, when many of our former employees were returning from service to re-enter industrial life.

Anticipating our future needs in the area of supervisory, executive and technical employees, the Glass Factories Manager, John W. Fisher, instituted a plan of training on a broader scope which would expose the trainee to all the phases of the glass container business prior to his assignment to a specific job.

Virgil J. Cox

The first step was taken with setting up a Training Board composed of The Executive Vice-President of the Company, The Glass Factories Manager and Assistant, The General Superintendent of the Muncie Division, The Production Superintendent, The Personnel Manager and The Training Director.

The Training Director, Virgil J. Cox, was assigned the responsibility to direct the program, establish the necessary controls to detect the progress, aptitude and special abilities of the individual trainee. A program was designed embracing specific training assignments in all departments of the organization.

A questionnaire covering each section is furnished the trainee when he begins an assignment, and he is required to file a report in answer to all questions upon completion of the time allotted to a department.

Class-room sessions are scheduled weekly during the early part of the program. To these meetings we bring members of our Supervisory and Technical Staff to lead informal discussions and demonstrations relative to their particular activities in the business. Of special interest to the group is the appearance of some of the "old-timers" who have spent most of their working years in the glassmaking trade and can ably describe the developments that have taken place in the industry, beginning with hand-blown methods through semi-automatic and automatic processes.

Special problems arising in the plant are subjects for class-room sessions. If a fact-finding survey needs to be made, the trainee group is assigned the task to investigate, analyze and prepare the reports. One member of the group is appointed to act as chairman and is responsible for organizing sub-committees and assigning duties to each member. Such surveys are conducted under the general supervision of a department supervisor who poses the situation to be studied.

Emphasis is placed upon the study and application of labor contracts in the operation of each department. Contracts are in effect with five separate local unions, which lend a variety of provisions to be considered in the overall operation of the plant. Simulated and actual grievances are entered as class-room topics and the trainees are divided to represent management and labor during such discussions.

Organization charts of each department are prepared

by the trainee during his tour through the program. He is also required to prepare man-hour budgets and determine the unit cost on a man-hour basis for each job classification in the department.

PROGRAM OUTLINE

Section	*Time*	*Department*
I	1 Month	Mold Engineering
II	1 Month	Mold Shops
III	3 Months	Forming Departments
IV	3 Months	Laboratory, Batch and Furnaces
V	1 Month	Packing, Carton and Decorating
VI	3 Months	General Engineering
VII	1 Month	Quality Control
VIII	1 Month	Warehousing and Shipping
IX	1 Month	Scheduling—Glassware and Cartons
X	1 Month	Accounting and Purchasing
XI	1 Month	Timekeeping and Payrolls
XII	1 Month	Sales
XIII	1 Month	Personnel and Industrial Relations
XIV	1 Month	Public Relations
XV	2 Months	Plant Maintenance
XVI	1 Month	Food Laboratory
XVII	1 Month	Industrial Engineering
Total	24 months	(Sections not necessarily to be taken in sequence)

When a trainee is assigned to the Mold Engineering Department for thirty days' training, he receives the following questionnaire:

Section I. Mold Engineering Questionnaire

1. What is meant by Mold Engineering?
2. Is this design work based on engineering fact or practical practice?
3. What is meant by specifications of a container?
4. What is a design print? Purpose?
5. What are tool drawings? Purpose?
6. What is the purpose of a model?
7. What is meant by Mold Displacement? How is this factor determined?
8. What is shrinkage? How determined? How used?
9. What is meant by blank factor?
10. What is meant by blank run?
11. How is the shape of a blank cavity determined? For Lynch 10, JPM, IS Blow-Blow, IS 62 Process?
12. What is relationship of change in weight of glass to capacity for a given mold?
13. How does density of glass enter into problem?
14. What are vent holes and why used?
15. What is invert center and how is it determined?
16. Why is weight or amount of iron used in a mold important? How is it determined?
17. What is meant by a light weight container? List examples.
18. What are the major differences in information shown on mold drawings as compared to drawings covering a machine part? Why are these practices different?
19. What various materials are used for mold construction?
20. What is a template? How made and how used?
21. Assuming that it is necessary, at the request of a customer, to reduce the capacity of a 32-oz. container by $\frac{3}{8}$ oz., what methods could be used to accomplish reduction in capacity?
22. In substituting finishes on a container made by IS 62, what are the important factors which enter into the problem?
23. What are the major types of GCMI finishes?
24. What are the GCMI standard container types?
25. How would you select the best type of machine for the production of a container?

The questionnaires covering the Forming Department, each consisting of twenty to thirty-five questions, are prepared separately for: (a) Forehearths and Feeders; (b) Miller Machine; (c) Lynch Machine; and (d) IS Machine. A library is maintained containing drawings and specifications for the various types of machines; furnace design data; technical publications and trade journals.

In the scope of Personnel and Industrial Relations, the trainee finds himself committed to a program covering: (a) Employment procedures; (b) Interviewing and selecting of applicants for employment; (c) Records: Assignment, Transfer, Discharge, Lay-off; (d) Policies regarding transfer and discharge; (e) State Labor Laws; (f) Unemployment Compensation Laws and Regulations; (g) Plant Rules and Regulations; (h) Pre-employment medical examination requirements; (i) Workman's Compensation; (j) Group Insurance; (k) Plant Protection; (l) Procedures for the handling of grievances; (m) Safety regulations; (n) Special legislation affecting Veterans; (o) Apprentice training programs; and (p) Basic Federal Labor Laws.

The various members of the Training Board are available at all times to give individual attention and guidance to matters concerning the training program. The progress of each trainee is made a matter of record, and thus far we have not found it necessary to interrupt the training of any man for "unsatisfactory progress."

The success of the program depends upon four factors:

The ability of the department supervisor to instruct effectively.

Proper planning of the program so that the instructor knows in advance what he is expected to teach the trainee.

Selection of the best qualified men for training in the technical and practical functions connected with manufacturing our product.

Reasonable assurance that the "objective job" will be available when the formal program is completed.

UNIVERSITY OF ILLINOIS MAKES APPOINTMENTS

The University of Illinois has announced the appointment of James A. Crookston to the A. P. Green Fellowship in the Department of Ceramic Engineering. This fellowship is to be devoted to the fundamental study of refractory problems.

Mr. Crookston received his B.S. degree in Ceramic Engineering at Missouri School of Mines in 1942 and, after graduation, worked on laboratory control work and on development work with the A. C. Spark Plug Division. In 1946, he returned to the Missouri School of Mines and received the Master of Science degree in June 1947.

Also announced by the University was the appointment of William A. Graff to the Owens-Illinois Research Fellowship in the Department of Ceramic Engineering. Mr. Graff received the B.S. degree in Ceramics in February 1946. The requirements for the M.S. degree in Ceramics are to be completed in September 1947.

SOME PRACTICAL ASPECTS OF THE SURFACE CHEMISTRY OF GLASS

By W. A. WEYL*

PART III

IV. Structural Changes of the Glass Surface and Their Technical Implications (*Continued*)

5. Reduction Processes. Glass containing the ions of heavy metals, such as copper, silver or lead, can be superficially reduced by exposing the surface to reducing gases at elevated temperature. Depending on the glass composition, concentration of the heavy metal oxide, temperature and time of exposure, a great variety of color effects can thus be produced. The effects obtained by surface reduction are complicated in character and cannot be easily interpreted. They result from the color of the metal produced, its reflectivity and the formation of thin films of different refractive index which in turn produce Newton-interference Colors. For centuries artists have taken advantage of these phenomena and a great many formulas for iridescence and luster colors have been developed in different glass plants.

If it ever should become necessary to describe more precisely these optical effects which depend on the angle of observation, one would have to use methods similar to those outlined by G. L. Buc, R. H. Kienle, L. A. Melsheimer and E. I. Stearns.[35] These authors describe and explain the phenomenon of "bronze" in surface coatings, especially in printing inks and paint films.

It is not necessary that the bulk of the glass contain the metal oxide to be reduced. By exposing the hot glassware to vapors of various metal compounds; such as tin, iron and bismuth salts, and on subsequent reduction, the same effects can be obtained.

According to the nature of these processes which were developed by artists rather than by glass technologists, little exact information is available in literature. We find a treatment of this subject in two papers by R. Zsigmondy.[36] In one treatise on "New Lusters and Colors on Glass", he describes the production and application of the resinates of silver, lead, iron, copper and bismuth.

In a later paper R. Zsigmondy[37] made an extensive study of the conditions which produce silver lusters of high reflectivity. He found it essential that the flux can dissolve a large quantity of silver oxide, preferably to be introduced in the form of the nitrate, without precipitation of metallic silver. Secondly, the reduction had to take place at a temperature where the glass was rigid. Reduction in the softening range led to an aggregation of the silver metal and destroyed the luster and mirror effect. Besides borax and low melting phosphates (microcosmic salt), especially the lead, cadmium and bismuth borates, singly or combined, were found suitable for brilliant lusters. Pure silicate glasses were found to be less suitable. However, the compositions, $K_2O \cdot PbO \cdot 6SiO_2$ and $K_2O \cdot 2PbO \cdot 6SiO_2$, were workable. The best results were obtained with a flux of the composition $2PbO \cdot 1.5B_2O_3 \cdot 3SiO_2$. For the reduction of the dissolved silver oxide, Zsigmondy used an alcohol flame.

L. Franchet[38] discusses the two possibilities; namely, incorporating the heavy metals into the glass or glaze and burning the metal compound into the surface. Either process is followed by reduction. Bernh. Müller[39] reports on his experiments to produce metallic lusters on glass by means of copper, silver and bismuth compounds and subsequent exposure to reducing gases.

Interest in the possibility of reducing a glass surface and thus forming metallic layers has been revived in recent years because of the optical and electrical properties imparted to glass by metallizing its surface.

E. H. Land[40] observed that glasses containing reducible metal oxides, such as PbO, can be used for making polarizing units. For this purpose the glass is partially reduced by exposing it to hydrogen or another reducing atmosphere, and subsequently stretched at a relatively low temperature. Under these conditions the lead droplets are brought into an elongated form, and thus produce an anisotropic structure in the otherwise isotropic medium. As a result the glass differentially absorbs two perpendicular components of an incident beam of light throughout a certain region of the spectrum.

In order to learn more about the influence which the composition of the base glass has upon reducibility, A. W. Bastress[41] made a systematic study of the reducibility of silver, bismuth, lead and antimony oxide by hydrogen gas in silicate, borate, borosilicate and some phosphate glasses. Silver ions can be reduced in some glasses below 100°C. The reduction of bismuth oxide to elemental bismuth required temperatures around 200°C.; lead oxide around 350°C.; and antimony oxide around 400°C. The temperature where reduction starts can be greatly influenced by the glass composition. In certain phosphate glasses, metal oxides resist reduction by hydrogen up to much higher temperatures than in silicate glasses. The addition of titanium dioxide increases the reduction temperature of metal oxides dissolved in silicate glasses.

Reduction processes are not limited to glasses containing heavy metal ions. P. Villard[42] observed that the inner surface of a glass tube containing hydrogen gas had devitrified due to the loss of alkali through reduction. M. A. Foëx[43] investigated the reducibility of a number of glasses at 1150°C. in hydrogen and found that potassium glasses were more readily reduced than sodium glasses.

The most direct way to bring about reduction is the bombardment of a glass with electrons:

$$Na^+ + e = Na$$

Bombardment with electrons not only reduces heavy metal ions but even alkali ions may be changed into the

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neutral atoms. With the development of electronic devices and light sources based on gas discharge, this type of reduction had to be avoided, and thus has led to the development of glasses and coatings of unusual compositions for the inner surface of vacuum tubes.

6. *Deposition of Metals and Compounds on the Glass Surface.* The reduction of metallic ions present in a glass, as described in the previous chapter, depends on so many variables that uniform films of high reflectivity cannot be expected from this method. Indeed, there is only one process which makes use of surface reduction for producing mirror effects. Surface reduction of a silver-oxide-containing plate glass has been suggested by A. D. Nash for producing a "one-way-vision" glass. To an observer looking through the glass from a dark into a well-lighted room, the glass remains transparent even after the formation of a very thin film of metallic silver in the surface layer. To the occupants of the lighted room, however, the same glass looks like a mirror.

All other types of mirrors are based on the deposition of metals on the glass surface. Silver is the metal most widely used, but for special purposes mirrors are manufactured by depositing aluminum, copper, gold or platinum metals on a glass surface.

The deposition of non-metallic compounds on a glass surface is of recent origin and has found commercial application only in the last ten years. By depositing non-metallic compounds on a glass surface, a number of interesting optical effects can be achieved. The best known and most widely applied method is decreasing the reflectivity of a glass surface. According to an equation derived by J. Strong,[44] the surface reflectivity of a glass having a refractive index n reaches a minimum if it is covered with a medium having an index equal to the square root of n. By building up layers of controlled thicknesses and various refractive indices, it is possible to produce nearly monochromatic light filters. For this purpose compounds of high refractive index, such as TiO_2 or ZnS, and others of low index (fluorides) have to be combined.

Although these phenomena were known for a long time, the deposition of these compounds on glass became possible on a commercial scale only with the recent development of high vacuum units. The fact that the reflectivity of a glass surface can be influenced by tarnishing or aging was observed by J. Fraunhofer[45] (1817) and by Lord Rayleigh[46] (1886). The latter found that the reflectivity of an old crown glass was only 3.5 per cent instead of 4.8 per cent. Repolishing the surface restored the original high value. The work of Fraunhofer on the tarnishing of glass surfaces and on chemical treatments of optical elements with acids shall be discussed in the next chapter dealing with the hydrolysis of the glass surface. Nearly a hundred years later, H. D. Taylor[47] thought of a practical use for this phenomenon and took out a patent (1904) covering chemical surface treatments as a means of decreasing the surface reflectivity of a glass. The aim of this process was to produce a faster photographic lens by means of an artificial, accelerated aging process.

The need for reducing surface reflection grew with the development of more complicated optical systems and the introduction of glasses with very high refractive index values. For glasses having a refractive index of 1.5, the percentage of light reflected from a single polished surface is 4 per cent. This value grows with the refractive index, according to a formula derived by Fresnel, and reaches 10 per cent for glasses having a refractive index of 1.92. During World War I, efforts were made to improve the Taylor process and to introduce it into production. These efforts of F. Kollmorgan, H. Kellner, J. B. Ferguson, F. E. Wright and later workers in this field shall be discussed in the next chapter. They deal with phenomena involving chemical attack of the glass surface in aqueous solutions and leaching out matter rather than the deposition of new layers.

The present chapter deals with the deposition of materials aiming at an increase or a decrease in the percentage of light reflected at the glass surface. The various processes can be conveniently subdivided into two groups. In the first group materials are deposited from a liquid phase and in the second group they are evaporated onto the glass surface in vacuo.

A) Deposition from the liquid phase. a) Deposition of silver. Silvering is by far the most important metal deposition on glass. There are numerous formulas for silvering glass but most of them fall into one of three groups, depending on the reducing agent: The Brashear Process (sugar as reducing agent), the Tartrate Process, the Formaldehyde Process.

The theory of these processes is based on the fact that the solution of a complex silver ammine salt does not contain sufficient silver ions to react with any of the above mentioned reducing agents. In the glass surface, however, the silver ammine reacts to produce hydrated silver silicate or silver ions adsorbed at the silica gel. These ions are reduced by the reducing agent and the silver atoms become centers of subsequent reductions. The metallic silver, so to speak, catalyzes the reduction of the silver complex and thus causes most of the metal to precipitate on the glass wall. The adhesion of the metal to the glass wall can be improved by treating the glass surface with stannous or titanous chloride solutions.

I. C. Gardner and F. A. Case[48] published a number of reliable formulas and gave an excellent description of the many points which must be considered. The importance of cleansing the glass surface is frequently underrated and, consequently, most of the failures in silvering can be attributed to improper preparation of the surface. The next chapter dealing with hydrolysis of the glass surface shall contain a detailed description of the factors which prevent complete wetting of the glass and which constitute possible sources of failures encountered in the manufacture of mirrors.

The preparation of the silver solution is another difficult step. Each of the three processes calls for a silver nitrate solution to which the proper amount of ammonia has been added. Insufficient ammonia results in undissolved silver oxide, thus changing the concentration and causing a loss. According to the law of mass action, a slight excess of ammonia reduces the silver ion concentration which in turn prevents the base exchange in the glass surface so that no mirror forms.

To insure the addition of the correct amount of ammonia, Gardner and Case recommended the following procedure: "Solutions A and B are prepared in accordance with the formula to be used. The ammonia, which should be C. P. and concentrated (specific gravity 0.88 to 0.90), is added to solution A in small portions, and

after each addition the solution is well shaken. At first the amount of precipitate formed will increase greatly with each addition of ammonia. The successive processes of adding ammonia and shaking the solution thoroughly are continued until the precipitate begins to redissolve and the further addition of ammonia tends to clear the solution. As the solution becomes cleared the ammonia should be added more cautiously and the duration of the intermediate period of shaking increased in order to give each portion of ammonia full opportunity to redissolve the precipitate as completely as possible before additional ammonia is added. It is desirable to add the minimum amount of ammonia that will redissolve the precipitate initially formed, but it is better to finish with a solution in which there is an excess of silver rather than an excess of ammonia. Accordingly, after one has added to solution A what is judged to be the requisite amount of ammonia, solution B is added in small amounts following the procedure that was used when adding ammonia. If only the correct amount of ammonia has been added the addition of a small amount of solution B will be followed by a darkening of the solution, resulting from the precipitation of silver oxide which will be permanent and will not disappear even if the solution is shaken thoroughly and allowed to stand for an hour or two. If, however, the ammonia has been added in excess the silver oxide will redissolve and the solution will clear. In this case one must continue to add solution B until the permanent darkening of the solution is secured. No attempt should be made to use a silvering solution until this darkening is obtained, even if it should be necessary to prepare an additional amount of solution B. If this procedure is followed a slight excess of silver is assured and the silvering solution is certainly in a condition to be readily reduced when used. The above-described precise method of determining the amount of ammonia to be added to the silver-nitrate solution is the procedure recommended when silvering is done at infrequent intervals, because in such cases there usually exists an uncertainty regarding the exact strength of the aqueous ammonia solution which is used."

The Brashear Formula.

The silver solutions:		
A	distilled water	400 cc
	silver nitrate	20 g
	potassium hydroxide	10 g
B	distilled water	30 cc
	silver nitrate	2 g
The reducing solution:		
	distilled water	1000 cc
	granulated sugar	90 g
	nitric acid (d = 1.42)	4 cc

In preparing the silvering solution, the chemicals are added in the order given. The potassium hydroxide precipitates silver oxide which has to be dissolved by ammonia as described above. The reducing solution is boiled for five minutes and allowed to cool before being used. One volume of the reducing solution is mixed with four parts by volume of the silver nitrate solution immediately before being applied to the glass surface.

The Tartrate Formula (Rochelle Salt).

The silver solutions:		
A	distilled water	100 cc
	silver nitrate	10 g
B	distilled water	30 cc
	silver nitrate	3 g
The reducing solution:		
	distilled water	1000 cc
	silver nitrate	2 g
	Rochelle salt	1.7 g

To solution A concentrated ammonia is added in the way described above and finally is diluted to one liter and filtered. The reducing solution is obtained by dissolving the silver nitrate in boiling water and adding the Rochelle salt. The solution is stirred while boiling for five minutes. It is then filtered before cooling and stored in a dark bottle.

Silver nitrate and reducing solution are mixed in equal volumes immediately before application.

The Formaldehyde Formula.

The silver solutions:		
A	distilled water	1000 cc
	silver nitrate	20 g
B	distilled water	100 cc
	silver nitrate	2 g
The reducing solution:		
	distilled water	200 cc
	formaldehyde	40 cc

Ammonia is added to solution A in the usual way, using solution B for the final adjustment. Five parts by volume of the silver solution are mixed with one part of the reducing solution immediately before application.

All three formulas are used at room temperature or slightly elevated temperature. For a detailed description of the application of the solutions and the protection of the mirror by lacquering or by coppering, see the original paper by Gardner and Case.[48] The theory of adhesion of these silver films and the role of "tinning" the glass surface were described by the writer in a recent publication.[49]

b) Deposition of copper. Whereas the silvering process is well understood, no satisfactory explanation was available for methods of depositing copper on a glass wall. Recently E. C. Marboe and the author[50] published extensive studies on this subject. Perhaps the most reliable method of producing copper mirrors on glass is the copper tartrate-formaldehyde process developed by M. Volmer.[51] Strictly speaking, this process is not the deposition of metal on glass but of metal on metal. It is based on the principle that a copper tartrate solution and formaldehyde react only in the presence of silver, copper or gold to form metallic copper. Other reducing agents which do not need noble metals as catalysts precipitate cuprous oxide rather than the metal. In contact with a glass surface free of noble metals, copper tartrate-formaldehyde does not react at all. Volmer, therefore, treated the glass wall so that it became catalytically active. As a nucleus for building up a copper mirror, a thin invisible layer of silver was used. This method gives very satisfactory results but from the viewpoint of surface chemistry of glass, it is less interesting than other methods.

Volmer recognized and properly interpreted the role of silvering, but the idea of utilizing the catalytic action of noble metals had already been known. Several patents on coppering solutions give formulas containing a soluble salt of gold or platinum in addition to the copper

salt and the reducing agent. B. Schweig[52] in a paper, "Colored Silvering of Glass", reviewed the patent literature on this subject and described some of the formulas.

It is not in the scope of this paper to give a complete survey of the literature. The purpose is to discuss only those methods which are interesting with respect to the surface chemistry of glass.

In silvering of glass, the surface plays an important role. The Ag^+ ions entering the surface layer are the ones which produce the initial reaction.

There is a method which in its mechanism corresponds exactly to the silvering process; namely, base exchange, reduction of the ionic copper in the glass surface to the metal atom and catalysts of the metal atoms influencing the progress of reduction.

This method is limited to cuprous ion-containing solutions. The first step, the base exchange, does not take place easily with cupric ions. The substitution of a monovalent Cu^+ for the monovalent Na^+ is more probable.

F. D. Chattaway[53] found that a copper mirror could be obtained by reducing copper salts with phenylhydrazine in alkaline solution. For this purpose pure, freshly distilled phenylhydrazine, $C_6H_5 \cdot NH \cdot NH_2$, is dissolved in hot water. A saturated solution of $Cu(OH)_2$ in ammonia is added to the warm mixture. The dark blue of the cupric ammonium ion disappears because the divalent copper is reduced to the colorless monovalent cuprous ion. Further reduction of the cuprous compound to the metal takes place if KOH is added to the mixture. The reaction, therefore, takes place in two steps as indicated in the following equations where the copper compounds are written as the respective oxides:

$$\text{I. } 2\,CuO + C_6H_5 \cdot NH \cdot NH_2 = C_6H_6 + N_2 + Cu_2O + H_2O$$

$$\text{II. } Cu_2O + C_6H_5 \cdot NH \cdot NH_2 = C_6H_6 + N_2 + 2\,Cu + H_2O$$

The first step takes place instantaneously. The second step requires time but can be accelerated by the participation of the glass surface. The cuprous silicate enters a base exchange and forms a cuprous silicate which is more readily reduced than the cuprous ions in solution. Once the first film of the copper metal is formed at the glass surface, the metal assumes the reduction potential of the reducing agent and the reaction proceeds rapidly at the metal-liquid interface.

The reducing action of the phenylhydrazine only theoretically leads to nitrogen and benzene, as indicated in equation II. Actually, side reactions cannot be avoided and, as a result, tarry products form and are dissolved in the benzene and interfere with a smooth copper deposition. This and the fact that the reaction must be carried out at about 80-90°C. and thus develop irritating vapors led E. A. H. French[54] to modify the process by replacing the phenyl derivative by a hydrazine salt. Hydrazine, $NH_2 \cdot NH_2$, can act as a reducing agent and thus form nitrogen. This reaction is not accompanied by the formation of tarry products. The lack of protective colloids, however, which in the case of the phenylhydrazine process prevent the autocatalytic progress of the reaction, causes the hydrazine process to proceed in the interior of the liquid independently of the glass surface. Thus only a small fraction of the copper deposits at the glass; the major part forms in the solution. French improved this condition by sponging the glass surface to be treated with the cuprous ion solution before applying the final mixture and he emphasized the importance of this treatment. This first step of the reaction leading to cuprous ions is used to provide a cuprous ion-containing glass surface. The addition of KOH which liberates the hydrazine base completes the reduction to the metal.

c) Deposition of gold and platinum metals: The deposition from aqueous solutions of gold or the noble metals of the platinum group is of relatively little interest both from commercial and scientific viewpoints. The more noble the metal, the easier it can be precipitated from its salt solution. The problem of gilding glass, therefore, is not the reduction of the ion to the metal but the adhesion of the latter to the surface. More so than in silvering, one depends upon the proper preparation of the glass surface, the "tinning"; that is, the adsorption of metallophilic ions in the silica gel. Because of the nobility of gold, it is difficult to restrict its reduction to the glass-liquid interface. All gilding solutions precipitate colloidal gold which grows and settles on the glass plate. By changing temperature and concentration of the reacting solutions, one can control the gilding process to a certain extent.

As far as the patent literature is concerned, attention shall be called to a paper by B. Schweig[52] on "Colored Silvering of Glass". This author recommended a formula which neutralizes a gold chloride solution with sodium carbonate and uses formaldehyde as a reducing agent:

Formula for gold mirrors:

Solution A	distilled water	80 cc
	gold chloride (50-51%)	3 g
Solution B	distilled water	80 cc
	sodium carbonate, cryst.	8 g
Solution C	distilled water	80 cc
	formaldehyde (40%)	4 cc

For gilding, equal parts of the three solutions are mixed and diluted with distilled water to a concentration depending on the method of application. If poured on a glass and allowed to stand for twenty minutes, the gold solution should have a metal concentration of about 0.2 per cent, that is of the same order of magnitude as that of most silvering solutions. The temperature required is 25°C. but can increase gradually to 30°C.

Spraying the solution against the glass requires much higher concentrations (1.25 per cent).

The rather limited interest in this type of gilding is only partly due to the high cost of the process. For scientific purposes, such as electrical measurements, gold or platinum metals offer the great advantage of being inert to atmospheric influences. However, for these purposes other methods of depositing metals are more widely used, Gold and the platinum metals can be easily deposited on the surface of non-conductors by cathode sputtering. For scientific purposes this method offers the best protection against contamination of the surface.

For commercial purposes, especially the decoration of glass, these noble metals can be easily burned in from organic solutions containing a soluble compound of the noble metal (H_2PtCl_6 in alcohol, gold sulforesinate in oil), a carrier such as collodium or lavender oil and, finally, a metallophilic ion (usually Bi^{3+} or Sn^{2+}).

d) Deposition of sulfides: The introduction of dark colored mirrors for rear-view mirrors in automobiles

opened a commercial application for an interesting reaction discovered by O. Hauser and E. Biesalski.[55] These authors found that thiourea, $S=C(NH_2)_2$, can liberate hydrogen sulfide in alkaline solutions and in the presence of heavy metal compounds can precipitate a mirror of metal sulfide. They gave the following formula for depositing a blue gray lead sulfide mirror on a glass plate (9 x 12 cm):

"One supports the plate upon four bits of paraffin in a suitable developing tray and flows over the plate a solution of 1 g of thiourea in 50 to 75 ml of water, adds 50 to 75 ml of a dilute solution of lead acetate and finally 25 ml of dilute potassium hydroxide or ammonia solution, mixing continuously. Immediately the white lead hydroxide becomes dark and after a short time is all changed into black lead sulphide, and a firm, uniform, and deeply black metallic sulphide mirror forms in half an hour, first upon the lower and then upon the upper side of the glass plate. For larger plates a somewhat longer time is required. Without further treatment it is then washed with water and dried."

For further development of this process and the pertaining patent literature, one may consult the above mentioned paper by B. Schweig.[52]

e) Deposition of silica gel: As mentioned above, the original methods for developing low reflectivity were based on chemical reactions which leach out certain or all glass constituents except silica. By replacing the alkali and alkaline earth ions by hydrogen or hydroxonium ions the surface of the glass changes to silica gel. These reactions shall be discussed later. Mentioned in this chapter are two processes which aim at the deposition of hydrated silica from a liquid phase.

The one process developed by A. R. Wood[56] in England consists in repeatedly wetting the surface of the optical element with a solution of silicon tetrachloride in a volatile non-aqueous solvent, such as carbon tetrachloride. After each coating the glass is exposed to the atmosphere until dry and the coating is rubbed until bright. After this procedure the glass is ready for the next coating. During exposure the glass surface has a chance to attract sufficient water from the atmosphere so that the silicon tetrachloride is hydrolyzed according to the equation:

$$SiCl_4 + 4\,H_2O = Si(OH)_4 + 4\,HCl$$

In order to prevent the glass surface from becoming water repellent by greasy impurities present in the solvent or in the atmosphere, it has been found advantageous to add to the solution a small amount of hydrophylic substance, such as acetone. The number of wetting, drying and rubbing operations required to achieve the desired results depends upon the refractive index of the glass, the strength of the solution and the moisture content of the atmosphere. As a glass surface is successively wetted and dried its color changes and it has been found that for ordinary window glass the optimum is reached when its color becomes purple. For a solution of carbon tetrachloride containing 1 per cent of silicon tetrachloride and an addition of 3 to 5 per cent acetone, usually 7 or 8 dips are sufficient to change the color to purple. If treatment is continued after the color has changed to purple, the reflective power increases steadily and the purple changes first to blue, then to blue-green and finally to yellow-green.

In Germany another process was developed during the war which uses an aqueous solution of silicic acid in combination with a wetting agent for the same purpose. According to H. A. Tanner and L. B. Lockhart[57] of the U. S. Naval Technical Mission in Europe, this process was carried out at the Leitz plant at Wetzlar as follows: The colloidal silica solution consisted of one part water glass of the specific gravity 1.22, seven parts water, 1.5 per cent hydrochloric acid and 1.5 per cent naphthalene sodium sulfonate. This solution was aged 15 hours at 35°C. and then used within 24 hours.

The coating process consisted in warming the glass element to 35°C., revolving it in a centrifuge head and treating it with a few drops of the silica solution. A small amount of water was then added to wash off soluble materials and the coating dried with warm air before removing the glass element from the centrifuge. A surface was coated in less than a minute by this method. This silica coating had an apparent refractive index of 1.27 but was quite soft.

B) Deposition of metals and compounds from the gaseous phase. The participation of the glass wall in chemical reactions of gases is well known to the chemist. The deposition of AsH_3 or $Ni(CO)_4$ molecules impinging on the wall of a hot glass tube produces deposits of metal often in the form of mirrors. E. C. Marboe and the author[50] studied the decomposition of metal organic compounds, such as copper formate and platinum acetyl acetonate, with respect to conditions leading to adhering metal layers. Adhesion depends chiefly on the condition of the glass wall. In vacuo, where the adsorbed water is kept to a minimum, well adhering metal films can be obtained through the thermal decomposition of these metal organic compounds. Despite the growing technical importance of metallization from the vapor phase as well as deposition of volatile salts on glass in vacuo, these processes shall be discussed only briefly because in most of them there is little opportunity for surface chemical reactions to occur. The chemical bonds which form are no doubt metal-oxygen bonds. The first layer of the impinging metal atoms reacts with the hydrogen glass by replacing hydrogen ions under liberation of hydrogen gas. In a later stage the metal atoms build up their own crystal lattices. In the case of halides, such as MgF_2 or Na_3AlF_6, the adhesion is based on a continuation of the glass structure by means of other ionic building units. Compounds, such as CaF_2 or NaF, are soluble to quite some extent in the glass melt and must be considered compatible with the structure of the silicates. It is obvious that the structure of the glass surface must have some influence upon the deposition of the first layers of the salts. For practical purposes, however, this influence is probably negligible because the deposition of salts from the vapor phase leads to crystals which, as a whole, are far from perfect. Through adsorption studies, DeBoer[58] and his collaborators revealed that these salt layers have a great "inner surface". They consist of laminae and have a lower refractive index than a well-developed crystal. In one way this is a desirable feature for the production of coatings for decreasing the reflection on the surface because the aim is for the production of layers of low refractive indices. On the other hand, however, these porous layers are mechanically weak and are likely to adsorb gases and vapors during use, thus changing

(*Continued on page* 370)

THE SELECTION AND INSTALLATION OF THERMOCOUPLE EXTENSION LEADWIRES*

The accuracy of any pyrometer system can be no better than the inherent precision of its components. Generally, the user will exercise the utmost care in the selection of an indicating or recording instrument with a high degree of accuracy or a precision thermocouple, but will frequently neglect the all-important factor of the wiring between the two. Even though proper consideration has been given to such factors as the ambient temperature gradient between the thermocouple and the indicating instrument, and the mechanical protection of the leadwires, the less common aspects of the electrical-mechanical installation and the insulation properties are often glossed over.

The temperature indication in pyrometry is obtained from the measurement of the emf developed by a thermocouple. This emf is determined by the temperature differential between the hot and cold junctions of the thermocouple. If the thermo-electric circuit were confined to the thermocouple proper, variations in the temperature at the cold junction (terminal head) would introduce an intolerable error. However, when suitable extension leadwire is used to extend the thermocouple to the instrument and thus locate the cold junction at a point where changes in its temperature can be easily and accurately compensated, the required degree of precision can be attained.

When extension leadwires are used (as they are in practically all pyrometer installations today) they become a part of the thermoelectric circuit and the thermocouple actually consists of the extension leadwires plus the thermocouple itself. Hence, the thermoelectric characteristics of the metals used in the extension leadwires are as vital as those of the thermocouple proper.

The importance of providing protection for the thermocouple proper is appreciated by all experienced users of such devices. In like manner, the proper protection of the extension leadwire is of equal, if not greater, importance, since it is not generally an expendable part of the installation and frequently costs as much as, or more, than the thermocouples and instruments combined.

In all instances, choice, layout and installation of leadwires are important and these factors become increasingly so as the numbers and lengths of the leadwires necessary to an installation become greater. In installations, such as brick yards, engine testing laboratories, steel mills, blast furnaces, and coke ovens, where extension leadwires are used under wide ambient temperature conditions and subject to many deleterious factors, such as weather, corrosive atmospheres and the like, the possibility of future maintenance difficulties and operational inaccuracies are multiplied.

Inasmuch as the emf generated by a thermocouple is, at the most, only about 50 millivolts (0.050 volts), very minute leakage or galvanic action can produce serious inaccuracies in the temperature indications by changing the emf applied to the instrument. Therefore, the moisture-resistant qualities of insulation, which guard against the possibilities of leakage or galvanic action, are primary factors to consider. The weather, heat, and corrosive atmosphere resistant qualities are of equal importance in forestalling leakage, direct shorts, and grounds.

Where process control is dependent upon the consistent operation of the thermocouple system, the importance of leadwires is multiplied because the product quality and production is in jeopardy if leadwire troubles should arise. As a general rule, in industrial processes, heat and dryness, no less than moisture, are potentially dangerous factors. Heat will dry some insulations so that they become brittle, highly absorbent, or actually destroyed. It must be borne in mind that leakages and similar effects, which would be inconsequential at higher voltages, such as 110 volts, or even at one volt, produce serious errors in the minute voltages common to thermocouple circuits.

For the purpose of clarity, the technical aspects of extension leadwires will be divided into two general parts: Wire and Insulation. The considerations for each in relation to a specific installation are entirely independent of one another. Therefore, by fulfilling the requirements as to the type of wire *and* the type of insulation, the proper extension leads for the specific case at hand can be ascertained.

As was previously stated, the emf developed by a thermocouple is determined by the temperature differential between the hot and cold junctions of the thermocouple. Since the extension leadwires are intended to extend the cold junction point to the end of the extension leadwires, they *must* have thermoelectric characteristics which conform to those of the actual thermocouple wires. Otherwise, at the junctures between the actual thermocouple wires and the extension leads, there would be a thermoelectric effect which would result in erroneous readings.

While in most cases the same metals are used in the extension leadwires as are used for the thermocouple wires themselves, there are times when this is economically impractical. However, if the thermoelectric characteristics of the extension leadwires and those of the thermocouple itself conform, the same results are obtained, regardless of the materials used. For example, it is economically prohibitive and unnecessary to use Platinum-Platinum Rhodium extension leadwires with a Platinum-Platinum Rhodium (QR or HER) thermocouple. Consequently, a cheaper combination of metals whose thermoelectric characteristics conform within the required limits is used to obtain entirely satisfactory results.

In so far as the size or gauge of wire is concerned, there is only one factor of relative importance to be considered, and that is the effect of external resistance upon the indicating instrument. Where the calibrated galvanometer (millivoltmeter) type of instrument is used, the resistance of the external leads should be as low as practical, especially where multiple measurements are made from thermocouples located at greatly varying distances from the instrument. Usually #14 B&S gauge wire is

*A condensation of a paper by C. C. Roberts and C. A. Vogelsang of the Brown Instrument Company, Philadelphia, Pa.

used. Where the galvanometer actuated potentiometer type of instrument is used, somewhat smaller wire can generally be used since the degree of accuracy is not dependent upon the external resistance in the circuit. As a rule, #16 B & S gauge wire is used. Where an instrument, such as the electronic type is used, external resistance has negligible effect upon its operative characteristics and extension leads as small or smaller than #20 B & S gauge can be used.

For the majority of installations, solid conductor wire is used; however, where the thermocouple is moved from one application to another, necessitating flexible extension leadwires, the stranded type of conductor must be used in order to avoid frequent breakage.

The insulation surrounding the extension leadwire conductors must act not only as a dielectric (have high electrical resistance) between the two conductors and between the two conductors and ground, but must act as a protective covering to exclude the entrance or absorption of any deleterious materials which would give an unfavorable electrical reaction.

Primarily, the insulation must be a good dielectric. It is of the utmost importance that the dielectric strength (insulating qualities) remain effective throughout any conditions of temperature, humidity, corrosive atmosphere, etc., to which the leadwires may be subjected. For this reason, various kinds of material are used for insulation. For example, it is often necessary for the extension leadwire insulation to withstand weathering in such open air installations as brick or coke ovens. In such cases, the insulation must be able to withstand both excessive wetting and excessive baking by the sun without any serious deterioration in the dielectric strength of the insulation. In installations where the leadwire is not subject to weather deterioration, other detrimental conditions, such as steam, flame, corrosive atmosphere, and heat must be considered in so far as the insulation is concerned, and an insulation capable of withstanding these conditions selected.

Examination of the cross-section of a piece of extension leadwire, shows that there are two, or sometimes three layers of insulation. The insulation directly around the conductors is a protective covering with a high dielectric strength and provides the primary electrical insulation. The outer insulation binds the two conductors into cable form and furnishes electrical isolation from the conduit or ground and mechanical and chemical protection. Both the inner and the outer insulations should be of a material which is resistant to both physical and chemical deterioration so that the dielectric properties of the leadwire remain effective. This is especially important in installations where it is difficult to replace the leadwire if trouble should develop.

To protect the extension leadwires from mechanical wear and tear, when necessary, a metal protection is used. This is generally in the form of either iron or steel conduit or a lead sheath. The use of lead sheath is desirable in installations where excessive moisture or corrosive atmosphere is encountered. The use of conduit is requisite when there is danger of mechanical abrasion or penetration which could result in the destruction of the insulation.

Types of Extension Leadwire Available

Extension leadwire is available both in different kinds of insulation and in different metal conductors. In this way, extension leadwire with thermoelectric properties to conform to any thermocouple *and* with insulation to fit any installation condition is available. The following list of the most commonly used thermocouples shows the kinds and sizes of the extension leadwire which are supplied:

Checking the thermoelectric characteristics of extension leadwire at Brown. Ends of samples protruding from small furnace have been welded together. Furnace temperature is kept at known degree. Opposite sides of sample can be seen inserted in ice water thermos type container.

Iron-Constantan (IC) Thermocouples—14-gauge solid conductors, 16-gauge solid or stranded conductors consisting of a positive conductor of iron and a negative conductor of constantan.

Chromel-Alumel (MA) Thermocouples—15-gauge solid conductor, 16-gauge solid or stranded conductors consisting of a positive conductor of copper and a negative conductor of constantan. Also, 14-gauge solid conductors consisting of a positive conductor of chromel and a negative conductor of alumel.

Because of the cost of Chromel-Alumel leadwire, copper-constantan leadwire, which is less expensive, is used for installations involving thermocouple terminal head temperature up to about 250° F. Above this temperature, the relationship between the temperature and the developed emf for copper-constantan becomes increasingly different from that of chromel-alumel, thus making it necessary to use the more costly chromel-alumel combination to avoid serious errors in the temperature indications.

Platinum-Platinum Rhodium (QR or HER) Thermocouples—16-gauge solid or stranded conductors consisting of a positive conductor of copper and a negative conductor made of a special alloy. (Leadwires of the special alloy and copper were developed to be equivalent in their thermoelectric characteristics with Platinum-Platinum Rhodium. This was necessary inasmuch as Platinum is a noble metal and consequently quite costly.)

Copper-Constantan (CC) Thermocouples—20-gauge conductors consisting of a positive conductor of copper and a negative conductor of constantan.

The foregoing list of conductors is available with different kinds of insulation, so that specific installation conditions can be met. *Not all* conductors are available in *all* types of insulation, inasmuch as industrial require-

(*Continued on page* 378)

ITALY'S GLASS INDUSTRY SETS PACE IN RECOVERY

The glass making industry in Italy, with centuries of tradition behind it, has made remarkable strides in recovery from the effects of the late war and in terms of employment and certain phases of production has surpassed pre-war figures, a direct contrast to other Italian industries.

The Italian glass industry, which before the war employed about 24,000 workers, now has approximately 30,000 on the payrolls. Developments in production have become more sensible and practical, especially in the manufacture of flat glass articles and of commodities in common use. However, like all Italian industries, the glass makers are plagued by scarcity of essential materials and ever-increasing costs of production.

Glass making factories as a whole did not suffer any great damage during the war and for the most part the plants were able, when the war ended, to resume their normal activity, notwithstanding the deficiency of coal. Lignite and wood were used instead. Exceptions were the Saint Gobain plants of Pisa which were completely destroyed, the Balzaretti Modigliani factory of Leghorn that was heavily damaged, and the Barra flat glass factory in Naples where the laminating plants were completely demolished.

The Italian glass making industry consists of five main categories: flat glass production; white glass articles in common use, including small bottles; bottles, demijohns and flasks; technical articles for laboratories, phials and glass insulators; and Muranese artistic glass.

The most important centers of glass making in Italy are Venice, for artistic products; Lombardy, for glass in common use, especially glass made by machines; Tuscany, for manufacture of flasks and demijohns; and Naples, for production of articles in white glass. The plants for flat glass and products made from flat glass are located in Porto Marghera, near Venice; Milan, Leghorn, Pisa and Naples.

What has and is taking place in the industry can be determined by examining developments in the various categories.

Production of pane glass for windows in 1942 totaled six million square meters. In 1946 this production had increased to 9,800,000 square meters, demonstrating the effort the industry has made to produce this item which is in urgent demand on the Italian market due to reconstruction. This production will be augmented soon by the Barra glass works of Naples which is nearly rebuilt.

The output of window glass is nearly completely absorbed by the domestic market, regardless of the possibilities for exportation, especially to Greece, Turkey, Egypt and Switzerland, markets formerly dominated by German and Czechoslovakian products.

The Italian production of pressed glass used as covering for industrial establishments has been sufficient for the domestic market needs as well as providing for export possibilities. In fact there has been exportation of some important quantities of flat and pressed glass to Turkey and Switzerland.

War damage to plants engaged in the production of flint glass articles in common use was very slight, consequently production was resumed immediately and was completely absorbed by the Italian internal market. Italy never has exported flint glass of this category, although there is possibility of surplus production because of the lack of foreign commercial organization by the interested firms. However, these factories would be able to handle any important requests for exportation.

In the production of bottles and demijohns, automatic and semi-automatic machines are used, while flasks are produced by hand blowing. Output of these articles has been augmented considerably in order to supply the increased demands of the Italian market. This increase in demand has been brought about for the most part by growth of the liquor and wine industries in recent years due to gains in exports to foreign countries, particularly Great Britain and the United States.

The manufacture of technical articles in glass, especially laboratory ware, phials and insulators for electric power lines, also has increased considerably. The Italian market has completely absorbed this increase since medicinal laboratories had to restock supplies destroyed or stolen during the war and the repairing of the extensive damage to power transmission lines has called for large quantities of insulators.

In this field the Italian producers are looking forward to taking over the foreign markets, particularly in the Balkans and Egypt, which were formerly supplied from the Jena establishments in Germany which specialized in technical glass articles.

The artistic glass industry of Murano, which suffered no important damage during the war, has resumed completely its normal production and actually is working nearly exclusively on foreign orders, mostly from North and South America. In this section some important plants that were idle for more than ten years have been reactivated and all the factories have increased productive capacity.

Italian glass manufacturers openly admit that the industry is susceptible to greater development, but before such expansion can be realized they must have the assurance of more availability of fuel, especially high flame coal. Another item that is scarce and that retards the eventual possibility of development of the glass making industry is soda ash, production of which in Italy is limited to one plant, property of the S.A. Solvey at Rosignato, near Leghorn. This society had another establishment in Monfalcone, but since it is now located in the zone under Yugoslav control the factory cannot deliver its product to the Italian market.

Possibility of the Italian glass industry turning out new products is dependent upon the development, more than anything else, of plants for hardening or tempering of glass. Two processes are in use—air cooling and oil cooling. Since oil cooling is very expensive in Italy, this method is employed only for costly table articles.

A new factory in under construction in Pisa for the manufacture of a special product, new to Italy, under the trade name of "Opalvetra," which will be made under an American patent by Saint Gobain. This prod-

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INCREASED MOLD LIFE MAY RESULT FROM NEWLY DEVELOPED CLEANING PROCESS

A new process that gives promise of revolutionizing the cleaning of molds in the glass industry has passed the experimental stage and will soon be placed in actual operation in a New Jersey plant. The process employs a bath of molten salt of special composition, maintained at a temperature between 800° and 900°F. by an electrically heated salt bath furnace similar to those extensively used for heat treating in the metal industry. Credit for its development goes to the Ajax Electric Company, Inc., Philadelphia, Pa., manufacturers of Ajax-Hultgren electric salt bath furnaces.

Molds are immersed in the hot salt bath for approxi-

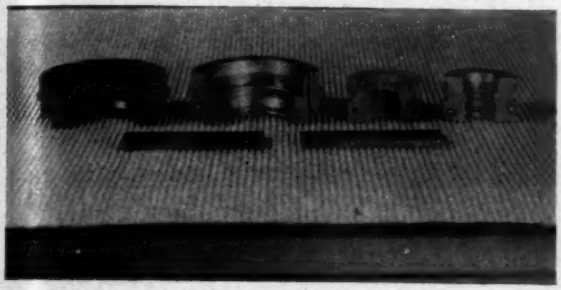

Fig. 1.

mately 20 to 50 minutes, during which time accumulations of carbonized oil and graphite are burned away and fire scale is chemically modified so that it can be removed so rapidly in an extremely dilute acid bath that there is no opportunity for the acid to attack the base metal. Whereas present methods of cleaning require that molds first be allowed to cool, the salt bath method permits hot molds to be placed immediately into the salt bath without danger and with consequent savings both in time and furnace heating costs.

Upon removal from the salt bath, molds are allowed to cool in air to between 400° and 500°F. before being quenched in clear water. This is done to avoid the danger of surface cracks which might be caused by too sudden cooling.

Following the quench, which serves both to complete the cooling and to wash off any salt film, the mold is given a "flash" dip in dilute (5 per cent) muriatic acid. The process is completed by a pressure spray rinse, a neutralizing dip and then drying or applying an antirust coating.

Fig. 2.

After cleaning by this method, mold cavities are free both of acid pock marks and of the matte finish caused by the abrasive effects of sand blasting. Very little buffing or polishing is required. Therefore the size is held and the useful life of the mold is multiplied many times.

The effectiveness of this salt bath cleaning process is clearly apparent in the accompanying illustrations. In Figure 1 the left halves of each of the two sets of necking molds are shown coated with carbonized lubricants and scale, while the mating halves on the right are shown after having been cleaned by this method.

That automatic molding machine parts, other than the molds themselves, can be cleaned quickly and thoroughly in the same manner is illustrated in Figure 2.

A similar process for the cleaning of rubber molds, also involving the use of Ajax-Hultgren salt bath furnaces, is already in successful operation in the plants of

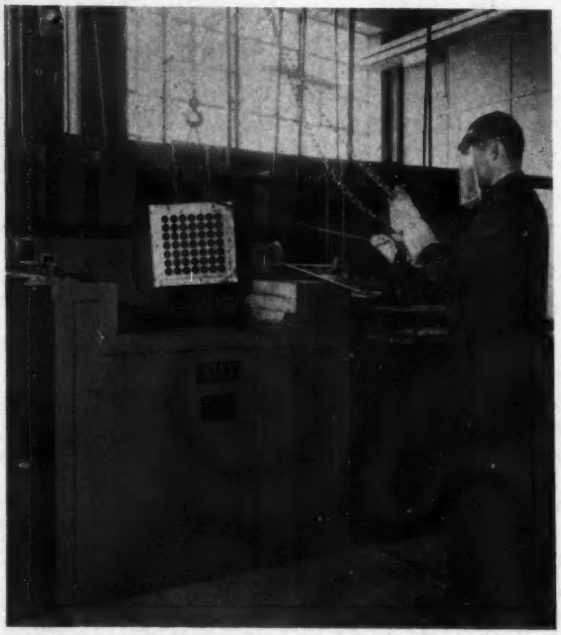

Fig. 3.

a number of manufacturers of molded rubber products. Figure 3 illustrates such a mold being lowered into the salt bath from an overhead hoist. Large glass molds are handled in the same manner, while smaller molds or machine parts may be placed in wire baskets or suspended by wires from simple, manually handled baskets.

Since the salt bath furnace is actually the heart of the process, a brief description of the Ajax-Hultgren unique heating principle should be of interest. A cutaway view of the furnace is shown in Figure 4. Heat is generated within the bath by the resistance of the molten salt to the passage of low-voltage electric current between two closely-spaced, immersed electrodes. Since heating takes place only between the electrodes, one would expect the heated salt to cause an upward circulation or "thermal flow." However, the close spacing of the electrodes cre-

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RECENT TRANSLATIONS OF RUSSIAN PAPERS OF INTEREST TO THE GLASS INDUSTRY

The originals of five papers, which appeared in the Russian journal, *Glass and Ceramic Industry*.

Production of Window Glass in U.S.S.R.

The output of window glass in U.S.S.R. was in 1940, 40 million square meters (about 430 million sq. ft.), in 1945, 18 million square meters (about 193 million sq. ft.), and in the first half of 1946, 11 million square meters (about 118 million sq. ft.). The plan for January-June 1946 was not fulfilled.

The yield of glass per square meter of the melting area of a glass furnace dropped after the war to 300-400 kg. per day. The main reason for this low yield is the substitution of sodium sulfate for soda ash in the batch. On soda ash the yield may be twice as high.

The rate of withdrawal of glass in Fourcault furnaces decreased to 40-45 meters/hour (about 130-145 ft./hr.), and the losses due to breakage rose to 30-40%.

The best performance, which other plants are urged to emulate, consists in producing 800 kg. of glass per day from 1 square meter of the melting area, and in withdrawing glass sheet at the rate of 70 meters/hour (about 230 ft./hr.). The above data are taken from *Stekolnaya i Keramicheskaya Promyshlennost* (Glass and Ceramic Industry) 1946, No. 6.

Polishing of Fourcault Window Glass

I. V. Grebenshchikov, N. N. Kachalov and A. V. Grigorieva report in *Stekolnaya i Keramicheskaya Promyshlennost* (Glass and Ceramic Industry) 1946, No. 7-8, p. 18 their experiments on polishing Fourcault glass with rouge (ferric oxide) powder.

Six variables were altered, namely (1) the fabric on

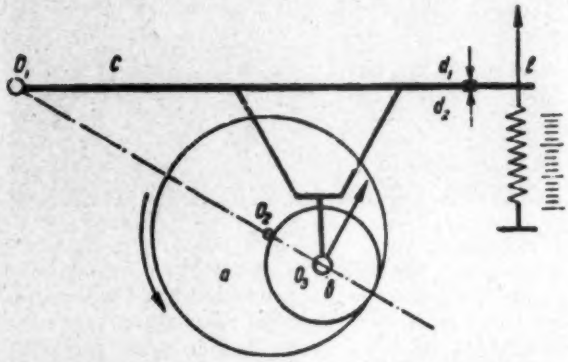


Fig. 1.

the polishing disc, (2) the amount of the rouge employed, (3) the pressure exerted by the polishing disc on the glass plate, (4) the relative speed between disc and glass, (5) soluble additions to water, and (6) the quality of the rouge.

The effect of these variables on two quantities was determined, namely (1) the amount of glass removed per unit time and (2) the frictional force between the glass and the disc. This frictional force was measured by means of the device depicted in Fig. 1. In it *a* is the glass plate rotating round the axis O_2, *b* is the polishing disc freely rotating round the axis O_3 and *c* is a rigid bar fixed in the point O_1 and also rigidly connected with the shaft O_3. When the glass plate rotates in the direction shown by the curved arrow, the shaft O_3 and therefore the bar *c* are pushed in the direction of the straight arrow. This push is resisted by the calibrated spring *e*. This spring is made tighter or looser so that the bar *c* remains in the original position, d_1 and d_2 are electric contacts which serve to define this position. When the bar touches d_1, the first lamp (not shown) lights up, and when the bar touches d_2, the second lamp not shown lights up. Both lamps emit intermittent light when the frictional force is exactly cancelled by the spring *e*. From the force exerted by the spring the frictional force is calculated with due regard to the different lengths of the lever arms O_1e and O_1b. The three points O_1, O_2 and O_3 are on one straight line.

Variable 1. There was no difference in the performance of discs covered with worsted (containing some cotton), with a Russian felt, or with a white foreign felt, except at the highest speed of revolution when the abrasion was more rapid when felts were used.

Variable 2. The amount of rouge used per plate, the area of which is not given, was varied from 1 g. to 5 g. The removal of glass by 3 g. rouge is about 1.7-2 times as rapid as by 1 g., but an increase of the amount of rouge from 3 g. to 5 g. has no effect. The glass surface is less scratched when 2-3 g. rouge is used than the amount 5 g. The frictional force increases with the amount of rouge but less rapidly than the abrasion of glass. E.g. the weight of glass removed by 3 g. is by 32% greater than that removed by 2 g. rouge, while the frictional force increases only by 12%. The amount of rouge employed was suspended in 15 cu.cm. water, and more water was added as necessary to offset the evaporation.

Table I.

Relative amounts of glass removed in unit time at different pressures and different speeds of rotation. The amount removed at 60 g.-weight per sq.cm. and 148 revolutions per minute is set equal to 1.

		revolutions per minute		
		148	214	470
Pressure g.-weight/sq.cm.	60	1	1.51	2.13
	90	1.7	2.04	2.89
	120	1.8	2.63	3.42

Variable 3. The pressure on the polishing disc was varied between 60 and 120 g.-weight per sq.cm. (0.84 and 1.7 lb./sq.in.). Table 1 shows that the amount of glass removed increased with the pressure and the relative increase depended but little on the number of revolutions per minute. The values given in this table as

well as in Table II were obtained using 2 g. of rouge and 15 cu.cm. of water on felt. Table II shows that frictional force increases with the number of revolutions per minute more rapidly than the amount abraded. This means that more work must be expended for removing a definite amount of glass if the removal is carried out under a higher pressure. Of course, the shortening of the time required may be more important than the augmented expenditure of work.

Table II.

Relative frictional force between glass and polishing disc at different pressure and different speeds of rotation. The friction at 60 g.-weight per sq.cm. and 148 revolutions per minute is set equal to 1.

		Revolutions per minute		
		148	214	470
Pressure g.-weight/sq.cm.	60	1	1.61	5.0
	90	1.53	2.73	6.6
	120	3.16	5.96	10.0

Variable 4. Tables I and II show also the effect of the relative speed of glass and disc. The amount abraded in unit time increases with the speed but the frictional force increases even more rapidly, so that the greater the speed, the more work must be spent on removing a definite amount of glass.

Variable 5. The amount abraded is different if, instead of water, 1% solutions of copper nitrate, copper sulfate, ferric chloride, ferrous sulfate or zinc sulfate are used. Ferric chloride proved to be the best addition agent: it increased the rate of abrasion by 30-40%. These good results could not be duplicated when polishing mirror glass.

Variable 6. There was no difference in the performances of rouge (a) prepared from ferrous sulfate and soda and then heated in a furnace at 750-800°, and (b) obtained by heating natural ferric oxide ore.

Mixing Reducer with Sodium Sulfate

Sodium sulfate is used in U.S.S.R. on a large scale as the source of Na_2O in window glass. The sulfate ion is reduced in the glass furnace by means of anthracite, coke, coal, peat or wood shavings. S.Ya.Raf, *Stekolnaya i Keramicheskaya Promyshlennost* (Glass and Ceramic Industry), 1946, No. 6, 7) studied some methods of mixing the reducing substance with sodium sulfate.

When wood shavings were mixed at once with all the other ingredients of the batch, a large proportion of the glass obtained was defective. Analyses of the batch showed differences in the concentration of the wood as high as 25 and 30%. It was found that a higher yield of good glass was achieved when the reducer and the sulfate were first mixed separately and then added to the rest of the batch.

Also when coal (1 part) was used for reducing sodium sulfate (11 parts), preliminary mixing of coal and sulfate improved the results. The degree of mixing was raised by using coal and sulfate of equal and small particle sizes: both powders passed through a sieve having 64 openings per sq.cm.

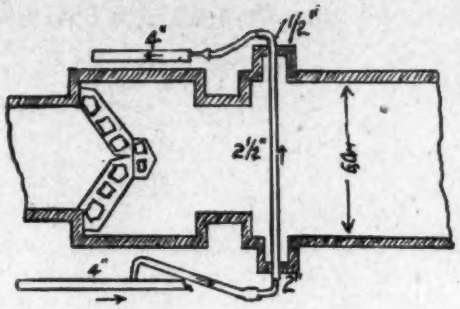


Fig. 1.

Water Cooling in a Fourcault Furnace

A. A. Tyagunov and M. D. Tamarin, *Stekolnaya i Keramicheskaya Promyshlennost,* (Glass and Ceramic Industry) 1946, No. 7-8, p. 6, tried out cooling glass with water in an iron pipe.

The iron pipe was placed across the Fourcault channel, see Fig. 1, so that it was partly immersed in the molten glass. The pipe was 9 meters (about 30 feet) long and had a diameter of 67 mm. (about 2.5 in.). Water of 8° C. (46° F.) entered the pipe, and the temperature of the outgoing water was 35° C. (95° F.), when the expenditure of water was 13 cu.m. per hour (about 460 cu.ft./hr.). The amount of heat carried away by the water was equal to 3.75% of the heat generated in the furnace by the producer gas.

A layer of very viscous glass, about 6 cm. (over 2 in.) wide forms on both sides of the cooler. This layer prevents scum from reaching the boat shown in the left hand side of the Figure. By regulating the heat conducted away by the water, the optimum temperature at the delivery end of the furnace can be achieved.

Moisture-Proofing of Triplex Glass

The usual Russian safety panes consist of two glass plates joined by a triple layer of gelatin-celluloid-gelatin. The high moisture sensitivity of gelatin makes the whole arrangement sensitive to humidity. A method of combatting this sensitivity is described by A. Ashkinasi in *Stekolnaya i Keramicheskaya Promyshlennost* (Glass and Ceramic Industry) 1946, No. 7-8, p. 9. After the pane is completely assembled, the organic film is burned out along the whole perimeter of the pane for the depth of 2-4 mm. (0.08-0.16 inch). This is done by means of an electrically heated steel knife, about 0.4 mm. (0.016 inch) thick. The groove thus obtained is cleaned with a rotating wire brush. The wires are 15 mm. (0.06 inch) long and 0.35 mm. (0.014 inch) thick, and the brush makes 800-900 revolutions per minute.

The cleaned groove is filled with a moisture-proof mass. This mass consists of petroleum bitumen No. 4 80 parts, rosin 10 parts, and linseed oil varnish 10 parts. It is applied hot. Steel discs, 0.35-0.40 mm. thick (0.014-0.016 in.), partly immersed in the molten mass, transfer it into the groove. The temperature of the mass must be controlled. Electric heating was found suitable for that.

• E. J. Brunning, President and General Manager of Consumers Glass Company, has been elected President of the Canadian government's synthetic rubber plant, Polymer Corporation, at Sarnia, Ont.

INVENTIONS AND INVENTORS

A Summary of Recently Issued Patents of Interest to the Glass Industry

Feeding and Forming

Marble Making Machine. Fig. 1. Patent No. 2,422,413. This machine is for making toy marbles and other spherical glass articles. It was invented by Oris G. Hanlon of Massillon, Ohio. The machine enables marbles to be made at an increased speed due principally to a new shear mechanism and chutes for guiding the gobs to the rolls.

As shown in Fig. 1 a stream of glass 6 flows downwardly from a melting furnace into a cutter guide 7 which is provided with a tapered opening 11. The bottom of the cutter guide has two funnels 12 and 13 into which gobs are delivered alternately by a reciprocating cutter 14. The cutter bar is provided with two cups 16 and 17 and an intermediate cup 18. A knife 19 is set into the top of the cutter bar and when the bar is reciprocated (by mechanism not shown), this cooperates with the cutter guide to shear gobs 20 from the stream 6.

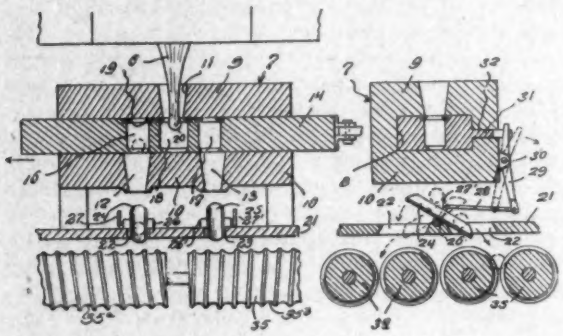


Fig. 1. Marble Making Machine.

The distributing mechanism comprises two chutes 24 and 25 mounted on a plate 21 below the cutter guide. The chutes are pivoted at 26 and arranged to be tilted so as to deliver gobs alternately to two pairs of marble forming rolls 34 and 35. The tilting is accomplished by levers 28 and 29 actuated by cams 31 projecting from the cutter 14. There are four pairs of rolls, two pair right and left and two pair front and rear. The chutes 24 and 25 deliver the gobs alternately to the front and rear rolls and the cutter delivers gobs alternately to the right and left rolls.

Due to the provision of three cups 16, 17 and 18 in the reciprocating cutter and the distributing chutes 24 and 25, the production of the machine is greatly increased. The following references are of record in the file of this patent: United States patents: 1,880,916, Early, Oct. 4, 1932; 1,898,407, Treece, Feb. 21, 1933; 1,993,235, Adams et al., Mar. 5, 1935; and 1,597,612, Morrison, Aug. 24, 1926.

Glass Compositions

New Corning Glass. Patent No. 2,422,472. This patent relates to a method of treating copper containing glass to produce color. It is the invention of Robert H. Dalton who assigned it to Corning Glass works. It was divided from the application which resulted in Patent No. 2,326,012.

In oxidized glasses, copper produces a green or bluish green color. When such glasses are melted reducingly, substantially colorless glass is produced if the copper content is sufficiently low and if cooled rapidly. Under proper conditions these glasses will become red if reheated. This invention increases the sensitivity to reheating and provides a glass which may be more sensitive to reheating in some parts than in others. This permits the production of a design in the finished article.

This inventor has discovered that exposure to short wave radiations will increase the sensitivity of such glass while in the colorless state. For example, if such glasses are irradiated with a quartz mercury arc, color may thereafter be developed by heat treatment at a lower temperature and in a shorter time. If this glass is reheated to a temperature near its annealing point, the irradiated portion takes the red color characteristic of copper ruby glass. Four examples of batches which can be used in accordance with this invention, are as follows:

	1	2	3	4
Sand	330	330	330	330
Sodium carbonate	139	139	139	139
Hydrated alumina	10.5	10.5	10.5	10.5
Hydrated lime	52	52	52	52
Copper suboxide	0.5	0.5	0.5	5.0
Sodium cyanide	3.8	3.8	...	...
Stannic oxide	...	1.2	1.2	1.2
Abietic acid	...	...	2.5	10

The patent gives directions for making designs on glass according to this method. The following references are of record in the file of this patent: United States patents: 1,169,571, Rosenthal, Jan. 25, 1916; 10,446, Locke, Feb. 5, 1884; 366,364, Atterbury, July 12, 1887; 2,314,804, Willson, Mar. 23, 1943; 282,002, Locke, July 24, 1883; 402,090, Leighton, Apr. 23, 1889; 2,075,446, Leibig, Mar. 30, 1937; and 2,326,012, Dalton, Aug. 3, 1943. Foreign Patents: 4,881, Great Britain, 1878; and 4,880, Great Britain, 1878.

Miscellaneous Processes

Sheet drawing Machine. Fig. 2. Patent No. 2,422,640. This machine is the invention of Hideo Yamamoto of Yokohama, Japan, and the title is vested in the Attorney General of the United States. It has been considered necessary to cool the sheet of glass as it is drawn uni-

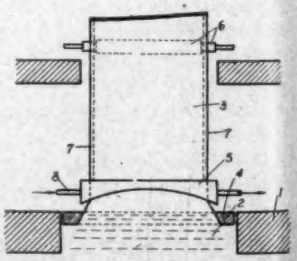


Fig. 2. Sheet Drawing Machine.

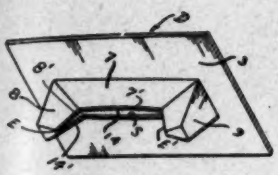


Fig. 3. Corning Sheet Glass Forming Apparatus.

formally across its width; that is, along a horizontal line. Sometimes the cooling has been greater at the center of the sheet. It should be noted that this patent is slightly confusing as the original application was apparently prepared by the Japanese inventor. It is stated that sheets made by this method were badly strained internally and of poor distribution. The merit of this invention seems to be in cooling the center of the sheet at a slower rate than near the edges.

Fig. 2 is a diagrammatic view of a sheet drawing machine made in accordance with this invention. The tank is represented at 1 containing molten glass 2 from which the sheet 3 is drawn by rollers 6. The cooling device of this invention is indicated at 5. This is cooled by water admitted through the pipe 8. Presumably the cooling device on the side adjacent to the sheet is curved in the same way that the bottom is curved. Thus the cooler is closer to the glass at the edges and therefore the cooling is greater there. The hardened edges first cooled are indicated at 7. It is said that much better sheet glass can be made in this way.

The following references are of record in the file of this patent: United States patents: 1,698,492, Drake, Jan. 8, 1929; 1,811,125, Halbach, June 23, 1931; 966,652, Colburn, Aug. 9, 1910; 1,688,530, Drake, Oct. 23, 1928; and 1,136,290, Stupakoff, Apr. 20, 1915.

Corning Sheet Glass Forming Apparatus. Fig. 3. Patent No. 2,422,466. This invention is designed particularly for drawing a very thin ribbon such as used for microscope cover glasses, insulation for condensers and so forth. It is the invention of Donald N. Brown who assigned it to Corning Glass Works. The invention resides in the shape of the nozzle or die through which the molten glass is discharged. This die is made of some highly refractory material such as platinum. The bottom of the die is in the form of a slot which is wider in the middle than at the ends. Apparently the narrower portions of the slot draws the glass toward the ends.

Fig. 3 is a perspective view of the die, looking upward when it is in working position. The flange 3 is secured to the bottom of the container of molten glass. It has a V-shaped central portion 7 and triangular extensions 8 and 9 shaped as shown in the figure. This shows the slot S as being wider in the middle and the end portions E and E^1 depending from the plane of the central part of the slot. This die permits drawing a sheet or ribbon with no bead on the edges. It is understood, of course, that the ribbon is drawn out in the usual way and that suitable cooling may be applied to the middle of the ribbon as it is drawn. The following references are of record in the file of this patent: United States patents: 1,548,444, Corl, Aug. 4, 1925; 1,670,167, Reece, May 15, 1928; 1,708,662, Clark, Apr. 9, 1929; 1,701,899, Spinasse, Feb. 12, 1929; and 1,759,229, Drake, May 20, 1930.

Danner Tube Drawing Machine. Fig. 4. Patent No. 2,420,934. This patent is an invention of Edward Danner of Newark, Ohio, who is well known as the inventor of highly successful tube drawing machines. Heretofore difficulty has been encountered in the manufacture of tubing having thick walls due to drawing lines produced by the shaping apparatus. This invention overcomes this trouble and also increases the speed of drawing.

As shown in Fig. 4 the furnace comprises a frame 1 carrying the various parts, which may be raised and lowered by a hydraulically operated piston 2. The tubing, shown in dotted lines, flows down onto horizontal rollers 3 carried by a frame 4 and by raising or lowering the furnace, the drag on the hot glass may be varied to change the diameter and wall thickness of the tube. The lower end of the furnace has sloping walls 5 and piers 6 support a conical block 7 above the opening 13. Narrow passageways 11 are formed between the supporting block and the walls of the heating chamber. A burner 14 below the opening 13 causes flame to surround the container 16 and to melt the batch therein. The products of combustion pass out through an opening 17.

A removable cover block 18 is over the top of the furnace. On the top of this block there is a damper 28 by which the effective area of the draft opening 17 may be adjusted. In the bottom of the container there is an outlet 29-31 by which all of the glass may be drawn off. A closure 32 is provided to regulate the flow of glass from the container. The position of the closure may be regulated by a wheel 38. The closure is water-cooled and the cooling is regulated by a valve 40. When the closure is opened, the glass flows onto a refractory block 48 which directs the glass to a chamber 49 from which it goes to the upper end of the shaping element 53 passing through a circular opening 54. The glass at this time is being heated by a burner 57 which keeps it at the desired working temperature. Blocks 59 may be

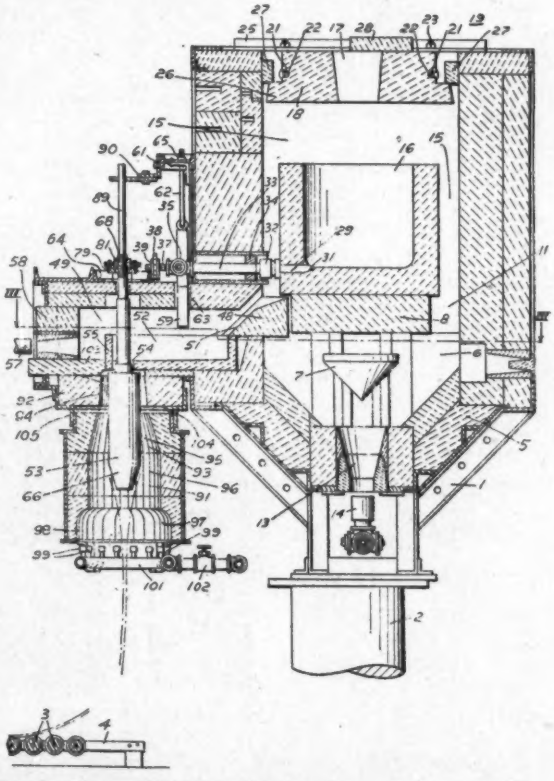


Fig. 4. Danner Tube Drawing Machine.

adjusted to control the heat.

The glass shaping element 53 is cylindrical and has a tapered end 66. This element is hollow and arranged so that the glass runs down both the inside and outside. A nut 81 permits the shaping element to be adjusted vertically. The element 53 projects into a shaping chamber 91 formed in a block 92. Below this there is a shell 93 having a bottom enlargement 97. Burners 99 discharge flame into the openings above and around the descending glass. A burner 105 is regulated to control the heat.

In this way the glass on the inside and the outside of the glass-shaping element may be independently heated to give a temperature difference which will tend to reduce devitrification.

This patent is a continuation-in-part of an application filed October 17, 1938. The following references are of record in the file of this patent: United States patents: 2,329,164, Stuckert et al., Sept. 7, 1943; 2,013,451, Stewart, Sept. 3, 1935; 1,219,709, Danner, Mar. 20, 1917; 2,131,417, Danner, Sept. 27, 1938; and 1,261,367, Danner, Apr. 2, 1918. Foreign patents: 612,120, France, July 24, 1926; 336,460, Great Britain, Oct. 16, 1930; 750,425, France, May 29, 1933; and 336,460, Great Britain, Oct. 16, 1930.

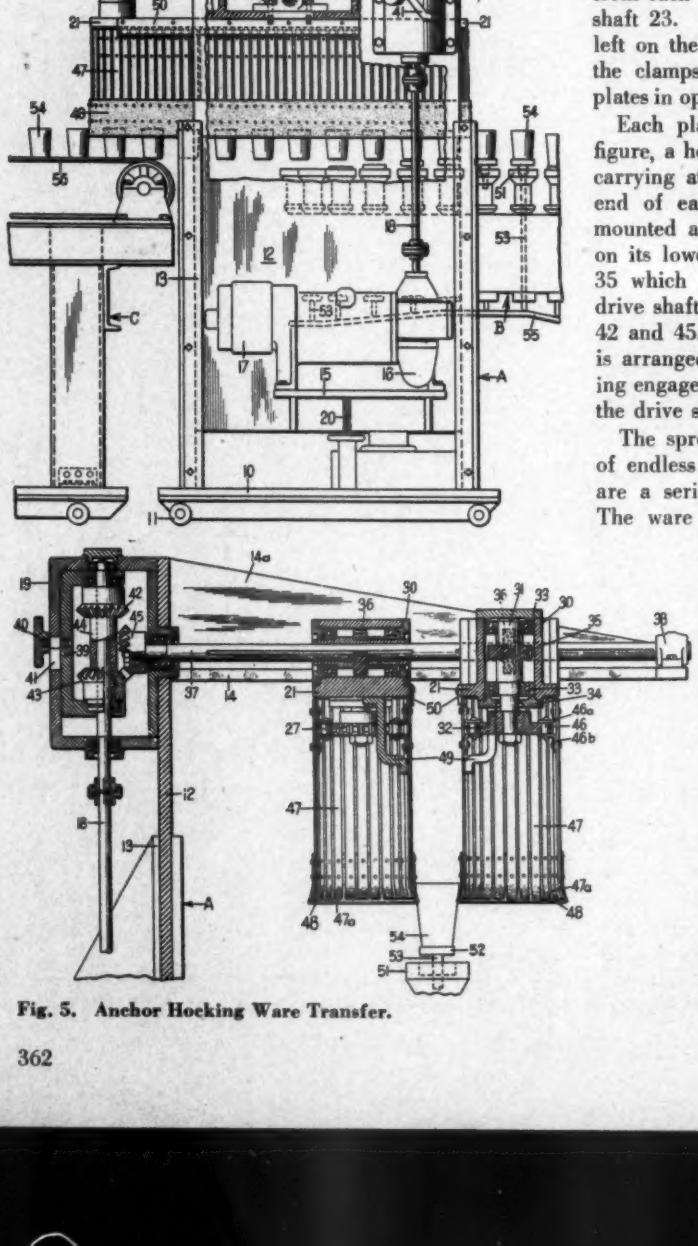


Fig. 5. Anchor Hocking Ware Transfer.

Anchor Hocking Ware Transfer. Fig. 5. Patent No. 2,421,515. This is an invention by William L. McNamara and Frederick Z. Fouse who assigned it to Anchor Hocking Glass Corporation. The invention is shown as used between a glazer and a conveyor but it is adapted for use wherever it is desired to transfer a row of articles from one moving conveyor to another. This device is power driven, portable and capable of various adjustments in position and speed which adapts it to use under widely varying conditions.

Fig. 5 is a plan view of this new transfer as used to remove articles from a glazer conveyor to another conveyor. A part of the glazer conveyor is shown at B and the conveyor to which the ware is conveyed is indicated at C. The transfer or take-off is mounted on a base 10 which is provided with casters so that it may be rolled from place to place as needed. A guideway 13 carries a vertically movable plate from which projects a horizontal bracket 14. The bracket has a pair of ribs 14a between which there is a slot 14b. A pair of parallel plates 21, are fastened to the bottom of the bracket by clamps 22. These plates may be adjusted toward or from each other by a hand wheel 24 fixed on a threaded shaft 23. The shaft is threaded right on one end and left on the other. As these threads each engage one of the clamps 22, turning the hand wheel will move the plates in opposite directions.

Each plate 21 has on its left end as shown in the figure, a housing 25 in which is mounted a vertical shaft carrying at its lower end an idler sprocket. The other end of each plate carries a housing 30 in which is mounted a vertical drive shaft having a sprocket fixed on its lower end. Each shaft also carries a spiral gear 35 which is engaged by a similar gear 36 fixed on a drive shaft 37. This shaft is driven through bevel gears 42 and 45. There are two gears 42 and the handle 40 is arranged to move one or the other of them into driving engagement with the gear 45 on opposite sides so that the drive shaft 37 may be driven in either direction.

The sprockets mounted on the plates 21 carry a pair of endless chains 46 and descending from these chains are a series of spring fingers which engage the ware. The ware engaging ends of these fingers are covered with some material such as asbestos indicated at 48. As the ware approaches on the glazer conveyor B it will be lifted by the valve common in such machines and grasped between the fingers on the chains 46. The ware will be carried along and released onto the belt 56 of the conveyor C.

The lower part of the figure shows how the fare is engaged by the ends of the spring fingers 47 and also details of the reversing mechanism by which the ware may be carried in either direction. The glazer supports are shown at 51. The stem rides on a track in the usual way to lift the ware 54 into position to be picked up by the fingers 47.

The following references are of record in the file of this patent: United States patent: 1,906,605, Hutchinson, May 2, 1933; 2,284,928,

(*Continued on page* 380)

Research Digest

Recent Developments in Glass-Tank Melting Furnaces

A few months ago, Professor W. E. S. Turner gave a lecture before the Pittsburgh Section of the American Ceramic Society on the subject of glass furnaces. The high-spots of his talk are summarized in this digest.

Efficiency and productivity of glass-tank melting furnaces have greatly increased in the last 20 or 30 years. A curve demonstrated this for the case of a tank furnace melting bottle glass. Up to 1916, the tank had been regularly producing on the average, 60 tons of glass per week, with a glass/coal ratio of 0.5:1. By 1936, this same tank, through improved technology, was producing 350 tons a week with a glass/coal ratio of 2.45:1. Additional data (Table I) were presented to show the improvement in rate of melting through application of improved methods in the case of another tank furnace melting colorless (container) glass. As shown in the table, the average melting rate, referred to as square feet of hearth area per ton per day, increased considerably over a period of nearly twenty years. In this same period, normal temperature of operation of the tank was increased from 1350 to 1510 deg. C—a factor in the increase of productivity.

Improvements in the technology of glass melting over the years were emphasized to have been evolutionary rather than revolutionary. Some of the improvement has been attained through adjustment of bath composition according to new batch formulae to take advantage of the higher melting rates and better adaptability of the new compositions to modern production methods. The high-lime glasses used 30 to 40 years ago were not found to give satisfactory results when automatic glass-forming machines were introduced. The reduction of the lime content and the adoption of soda ash to replace salt cake in the batch led to a greatly increased speed of melting with the production of glass giving better distribution under the conditions of operation although not as durable a glass. Further systematic work has led to greater durability combined with still speedier melting. Such studies on the effect of changes in batch composition are continuing.

TABLE I. OPERATING DATA FOR A GLASS-TANK FURNACE MELTING COLORLESS GLASS

Year	Average Melting Rate (Sq. Ft. per Ton per Day)	Operating Temperature (Deg. C)
1919	16.8	1350
1921	17 +	
1923	15.7	
1927	13.3	
1929	12.1	1420
1931	10.1	
1933	8.6	
1935	8.2	1480
1937	7.2	1510

Adequate mixing of the batch, and automatic-charging mechanisms have aided in improving homogeneity of the melt by distributing the charge uniformly and continuously rather than in large batches charged intermittently.

Higher furnace operating temperatures (see Table I) have increased productivity to a marked extent, as compared to earlier practice. Above 1400 deg. C, the melting rate of soda-lime-silica glass is practically doubled for each 50 deg. C rise in furnace operating temperature.

Consideration of the foregoing factors that affect productivity has been entirely apart from the question of furnace design. Undoubtedly design has undergone improvement. Size, shape and depth of the bath of a furnace, port design and port area, regenerative-system design, and volume of the checker work have all been the subject of study.

Due to the complexity of attempting to determine individual effects of the above factors, the trend in England in recent years has been to consider the furnace, its auxiliaries and the melt as a unit for study, rather than to concentrate effort on one or a few factors at a time.

An extension of the reasoning arising from this trend has resulted in regarding the heat input to the process as consisting of two parts: (1) that necessary to heat the whole furnace structure and to maintain the system and the glass at the desired temperature level, and (2) the heat required to melt new batch introduced into the system.

From this point of view, it is obvious that effort should be concentrated on means for reducing the quantity of heat required to heat the structure and maintain the desired temperature level to as low a figure as possible.

The ratio between (1) and (2) above can be taken as a basis for study of the process. A practical example of the relative importance of the two terms was provided by the fact that when tank furnaces were put on a 7-day instead of a 6-day schedule, only a small additional quantity of fuel (the amount actually required to melt new batch on the one additional day) was needed to obtain an added day's production.

An equation has been worked out by the Society of Glass Technology's Furnace Committee for calculating a numerical value, Q, which can be determined and used as a relative value for comparing tank efficiencies, as follows:

$Q = 0.026\ (GH/AK_aK_t - Wc/AK_a)$ where:

Q = quantity of heat required per second to maintain 1 sq. ft. of glass surface at 1400 deg. C (Btu. sq. ft./sec.)

G = total quantity of fuel consumed in the furnace per 24 hr. (tons/24 hr.).

H = net heat content of fuel (Btu./lb.).

A = total area of glass in the melting and working portions of the furnace exposed to the crown when the furnace is new (sq. ft.).

W = weight of glass discharged from the furnace every 24 hr. (tons/24 hr.).

c = quantity of heat required at the reversing valve of the furnace system (or equivalent position) to melt raw materials needed to yield 1 lb. of glass and raise its temperature to 1400 deg. C (Btu./lb.).

K_t = numerical correction factor when the furnace is working at some other temperature than 1400 deg. C.

K_a = numerical factor to enable correction of furnace area to be made to the standard of 600 sq. ft.

The formula was developed to provide means for evaluating thermal performance. It will be noted that the factors are referred to standard conditions, enabling comparisons to be made between different tanks.

It was stressed that the shorter the interval of time that the melted glass is held in the furnace, after the batch has been melted and made homogeneous, the lower will be the heat input required to maintain it at temperature and the better the efficiency of the melting process.

Although care and study are indicated before attempting too extensive application of insulation to glass-tank furnaces, there is no doubt that its use increases thermal efficiency. Various parts of the furnace structure can be insulated, thereby reducing the heat input required for maintenance of the desired temperature level.

Recommendations have been made in England for the insulation of furnace crowns, and the practice has been successful. A diagram of a typical insulated crown was shown to indicate one method of insulation employed. In this case, the crown consisted of a sprung arch, constructed of silica brick having the following dimensions: 12 in. by 4½ in. by 2¾-2⅞ in. Above the silica brick of the crown was laid a course of old silica brick, each 12 in. by 4½ in. by 2½ in., with sand brushed into the crevices between the brick. Above this was laid a second course of Fosalsil-Super insulating brick, each 9 in. by 4½ in. by 2½ in., with sand brushed into the crevices. The third and final course consisted of 9-in. by 4½-in. by 3-in. Economite insulating shapes.

An important consideration in melting glass is the problem of introducing heat where it will be most effective. Use of submerged electrodes, heated electrically, provides a means for applying heat where desired in the melt.

Use of electric heat for glass melting was stated to have been prompted in Switzerland by necessity, due to lack of other suitable fuels, rather than to any preconceived idea of increasing glass tank efficiency. The method has been under study and exploitation for a long period of years, especially in Europe, but real commercial success was first obtained through the work of E. Borel at Romont, Switzerland.

A series of diagrams depicted the development of the electric glass-melting furnace, illustrating steps in locating and relocating the electrodes to obtain the best efficiency. Pure graphite electrodes are employed for this service, to eliminate some difficulties experienced with electrodes fabricated from impure grades of graphite. Electrodes in use range from about 6 to 14 in. in diameter, depending upon the furnace in which they are used.

A claimed advantage of this method of heating is the promotion of better uniformity of melt temperature distribution. Also, furnaces using only electric heat are simpler to construct. However, unless economic conditions are such that very cheap electric power is available, it is most economical to employ conventional fuels for maintaining the temperature level of the furnace system and charge, and to employ electric heat only for melting added new batch and promoting bath-temperature uniformity.

Some operating data were presented for an all-electric melting furnace producing glass for sheet, using three-phase power. Operating temperature of the furnace was 1408 deg. C. Potential between phases was 120 volts.

TABLE II. EFFICIENCY OF ELECTRICALLY-OPERATED GLASS-MELTING FURNACES

(Ratio of Energy to Weight of Glass Produced)

Theoretical (neglecting furnace losses) = 0.6 kwh/kg

Product	Tank	Melting Rate (Tons/24 hr)	Melting Zone Refractory	Ratio of Energy to Weight of Glass (kwh/kg)
Window glass	A	24	Corhart	1.8
Window glass	A	24	Fireclay or sillimanite	1.5
Window glass	B	50	Corhart	1.5
Window glass	B	50	Fireclay or sillimanite	1.2
Bottle glass (green)	C	14		1.6-1.7

Current intensity per phase was 8800, 9300 and 9300 amp., respectively. The indicated power was 2000 kw. Glass produced was 24 tons per day.

Another use of electric heat mentioned was that of using electric resistors of the metallic type for controlling accurately the temperature of a drawing chamber.

Table II presents some additional data obtained from actual electric-furnace melting practice.

Use of electric melting for glass production was described as now established and in large-scale use.

Selection of any particular source of heat—gas, oil or electricity—will be largely governed by relative cost on a Btu basis, since there are no outstanding advantages of one over the other in general so far as glass quality is concerned.

A much fuller exploration of temperature distribution within glass-tank furnaces is to be desired. A substantial beginning has been made in the study of this problem, but more data are needed. Study of the different methods of temperature measurement is also indicated, to determine if and how they can be used in studies on glass-tank furnaces. A plea was made for cooperation between glass manufacturers in order to advance these studies.

SYLVANIA NAMES MERCHANDISING SUPERVISOR

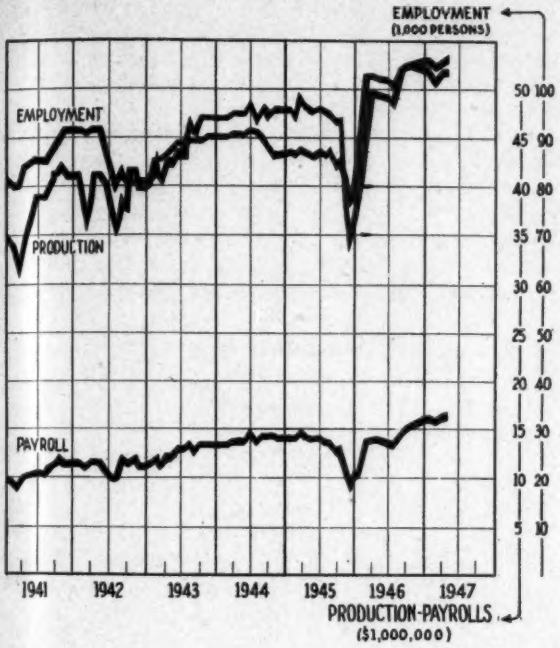
F. R. Archer has been named Merchandising Supervisor of the Fluorescent Lighting Fixture Division of Sylvania Electric Products, Inc., according to a recent announcement.

In his new capacity, Mr. Archer will supervise merchandising and promotional activities for fluorescent fixtures manufactured by the company. Previously, he supervised promotion and sales of cold cathode and photographic lamps and, during the war, was Product Manager of Marine Lighting, working with the submarine section of the United States Navy.

Prior to joining Sylvania as a field engineer in 1940, Mr. Archer was affiliated with the Barkon Frink Tube Lighting Corporation as Sales Engineer and the Westchester Lighting Company.

CURRENT STATISTICAL POSITION OF GLASS

THE GLASS INDUSTRY'S INDEX



During April 1947, according to the Production Index, activity in the glass industry increased close to 2 per cent over the previous month. The figure reported was an estimated $58,000,000, as compared with an approximate $57,000,000 production in March. During April 1946, production was an estimated $50,000,000, which is about 16 per cent below April this year. Total output for the first four months of 1947 has reached an estimated total of $226,500,000. During the corresponding period in 1946, the figure was $186,000,000.

Employment and Payrolls: Employment for April 1947 varied only slightly from the March figure and remained an approximate 104,000 persons. Employment during April 1946 was about 102,000.

Payrolls rose a little more than 1½ per cent and were about $16,250,000 for the month of April. The preceding month, they were $16,000,000. For April 1946, the payroll figure reported was an estimated $13,600,000. Total payrolls for glass manufacturers for the January-April 1947 period have reached an estimated total of $63,750,000 as compared with $40,700,500 during the same period in 1946.

Glass container production, based on figures released by the Bureau of Census, rose about 2 per cent to 10,556,354 gross produced during May 1947. The April production figure was 10,317,201 gross. Production during the month of May 1946 was 8,960,660, or 17 per cent below May this year.

Shipments for May 1947 dropped only slightly from the previous month's figure—May shipments were 9,889,718 gross and April shipments were 9,982,640. Shipments reported for the month of May 1946 were 9,414,367 gross, which is about 5 per cent under May this year.

Total shipments made thus far in 1947 have reached 49,395,607 gross, as compared with 47,714,040 gross shipped during the same period in 1946.

Stocks on hand at the close of May 1947 were 6,085,635 gross as compared with 6,085,635 gross at the close of April and 3,642,641 gross at the close of May 1946.

Plate glass production for the month of May 1947 rose about 8 per cent to 23,171,265 sq. ft. from the 21,419,088 sq. ft. produced during the previous month. During May 1946, plate glass production was 18,862,864 sq. ft., or 22 per cent less than May this year. Plate glass production for the first five months of 1947 has reached a total of 109,442,768 sq. ft. as compared with 74,874,478 sq. ft. produced during the same period in 1946.

Automatic tumbler production for the month of May 1947 rose 2 per cent over the previous month's pro-

GLASS CONTAINER PRODUCTION AND INVENTORY

(All figures in gross)

		Production May 1947	*Stocks May 1947*
Foods; Medicinal & Health Supplies; Chemicals, Household, Industrials; Toiletries & Cosmetics	Narrow Neck	3,256,828	2,475,235
	Wide Mouth	2,927,085	1,750,011
Dairy Products		333,003	193,842
Home Canning		219,181	668,496
Beverages, Returnable		1,052,712	458,132
Beverages, Non-returnable		.....	.....
Beer, Returnable		1,616,407	142,776
Beer, Non-returnable		167,976	14,359
Liquors		723,412	231,852
Wines		99,693	98,514
Packers' Tumblers		160,057	52,418
Total		10,556,354	6,085,635

GLASS CONTAINER SHIPMENTS

(All figures in gross)

	May 1947
Narrow Neck Containers	
Foods	1,006,727
Medicinal & Health Supplies	1,005,560
Chemical, Household, Industrials	441,252
Beverages, Returnable	962,463
Beverages, Non-returnable	.....
Beer, Returnable	1,517,213
Beer, Non-returnable	165,758
Liquors	664,790
Wines	92,284
Toiletries & Cosmetics	377,766
Sub-Total (Narrow)	6,233,813
Wide Mouth Containers	
Foods	1,931,409
Dairy Products	341,368
Home Canning	227,481
Medicinal & Health Supplies	328,215
Chemical, Household, Industrials	126,155
Toiletries & Cosmetics	132,478
Packers' Tumblers	143,153
Sub-Total (Wide)	3,230,259
Total Domestic	9,464,072
Export Shipments	425,646
Total Shipments	9,889,718

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duction—the May figure is 6,769,423 dozens and the April figure is 6,639,261 dozens. Production for the month of May 1946 was 5,978,089 dozens. Shipments for May 1947 also rose about 1½ per cent to 6,234,240 dozens. The April figure was 6,140,403 dozens. Shipments for May 1946 were 6,705,600 dozens. Stocks on hand at the close of May 1947 were 6,671,992 dozens, which is 6½ per cent over the 6,262,482 dozens on hand at the close of April. Stocks at the close of May 1946 were 3,936,676 dozens.

Table, kitchen and household glassware: Manufacturers' sales of machine-made table, kitchen and household glassware rose close to 6 per cent for the month of May 1947 to 3,652,808 dozens from 3,453,687 dozens sold during April 1947. Sales during May 1946 were 4,512,616 dozens. Total sales for the 12-month period ending May 1947 have reached 43,575,026 dozens.

FOUR PITTSBURGH PLATE GLASS ELECTRICAL CONTRACTS AWARDED

Electrical installations totaling $445,000 have just been completed or are under contract at three Pittsburgh Plate Glass Co. plants by Allegheny Industrial Electrical Co., Pittsburgh, Pa.

At the Creighton, Pa., Twindow plant, lighting and power systems will be installed under a $125,000 contract just awarded by The Austin Company, general contractor. Nearly completed is the electrical installation at a new paint plant at Springdale, Pa., under a $150,000 contract.

Expansion and modernization of the wiring system at the Mt. Vernon, Ohio, glass plant has just been completed. The $170,000 contract, awarded by The Rust Engineering Co., Pittsburgh, included the installation of new control equipment and change over to a new voltage without delaying production.

A.C.S. SECTION MEETINGS

The Trenton Section of the American Ceramic Society held its third meeting of the year recently. Mr. L. G. Bliss, Director of Distribution of Foote Mineral Company, presented a talk on "The Silver Side of Lithium", dealing with the history and uses of this element which has become of comparative importance recently. The next meeting of this Section has been announced for September, and Clifton H. Cox, Industrial Consultant of Newark, N. J., is scheduled to speak on "The Supervisor's Management Job".

The Pittsburgh Section of the Society closed its year with its annual Ladies' Night dinner and dance. Arthur Wells, of Homer Laughlin China Company, and Don Schreckengost presented the Homer Laughlin Very Little Theatre Group, whose program was very well received. A. P. Thompson, retiring Chairman of the Section, introduced the new officers whose term begins immediately.

The Northwestern Ohio Section held one of its most successful Summer Meetings. A day of golf was interrupted by heavy rains which necessitated a drawing for the golf prizes. After dinner, drawing for prizes was held and a skit presented. Mr. C. S. Pearce, General Secretary of the Society, then spoke briefly followed by John D. Sullivan, President of the Society. Mr. Sullivan spoke on Ceramic Engineering Materials.

SETTLEMENTS APPROVED IN HARTFORD-EMPIRE CASE; WILL BE SOLD OUTRIGHT

Under terms of a settlement approved by the Federal District Court at Toledo, O., in the long-drawn-out Hartford-Empire case, the Hartford-Empire Company will sell outright its current lines of glass-making machinery to container manufacturers, at the latter's request, instead of leasing the machines. Settlements also were approved between the Government and other defendants in the case: Hazel-Atlas Glass Company, Ball Brothers Company and Lynch Corporation.

The settlement with Hartford-Empire was the major one in the case. Under the provision for outright sale of glass making machinery, according to the Attorney-General's office, it is estimated that container manufacturers will save approximately $10,000,000 in royalty payments over the next five years, and "ultimately this saving should reach the consumer." (In this connection, industry sources pointed out that the actual saving per gross of containers would be very small.) The settlement further provides that container manufacturers may now make their own glass-making machinery or have it made for them by manufacturers of their own choice. Glass-making machinery manufacturers also will benefit from a reduction in royalty payments to Hartford-Empire, particularly on feeder machines.

A further provision of the settlement requires Hartford-Empire to dedicate to the public, as of October 31, 1950, three of its basic patents covering glass feeders.

Under separate settlement agreements with Hazel-Atlas Glass Company, Ball Brothers Company, and Lynch Corporation, glass-making machine patents have been made available to the public at "royalty rates designed to encourage their use." Owens-Illinois Glass Company had agreed previously to license its glass-making machine patents for the nominal single royalty of $1.00, and a similar settlement has now been made with Ball Brothers.

UNION PACIFIC CAMPAIGN TO CUT FREIGHT LOSSES

A Union Pacific-inspired campaign among the nation's railroads, manufacturers and shippers to cut freight losses due to damage en route is beginning to show signs of success.

Coincident with public circulation of a new folder giving shippers several tips on better packaging, G. F. Ashby, President of Union Pacific, revealed the railroad's latest service to shippers has brought favorable comment from them all, as well as indications that the idea is spreading rapidly to other lines.

In addition, the Association of American Railroads has circularized its members with a letter written by Mr. Ashby to W. T. Faricy, Association President, suggesting that all railroads employ container engineers to cut losses in freight damages en route.

• R. T. Risk, Secretary-Treasurer of Laclede-Christy Clay Products Company, was elected President of the St. Louis Chapter of the National Association of Cost Accountants. Mr. Risk, who is a Certified Public Accountant, is also affiliated with the American Institute of Accountants.

TOLEDO UNIVERSITY ESTABLISHES GLASS TECHNOLOGY PROGRAM

The University of Toledo has announced the establishment of a four-year undergraduate program in Glass Technology leading to the degree of Bachelor of Engineering.

Developed in consultations with representatives of Toledo glass firms, the new program will combine a sound training in basic subjects and offer specialization in glass and related fields. The program will be administered by the University's College of Engineering as one of its options and is scheduled to start in September. Full time faculty members and experts from the glass industry will share in the teaching. Dr. Clarence L. Babcock of the Research Division of Owens-Illinois Glass Company will be in charge of the initial course in Glass Technology.

Serving on the Advisory Committee are two other glass men, Mr. Victor W. Boeker, Assistant to the Vice President, Owens-Corning Fiberglas Corporation, and Dr. Oscar G. Burch, General Research Director, Owens-Illinois Glass Company. Other members of the Committee are Dr. John B. Brandeberry, Dean, College of Engineering, Dr. Walter V. Burg, Head, Department of Chemical Engineering and Dr. Raymond L. Carter, Dean of Administration.

The first two years of the course are identical with those of the Chemical Engineering option of the Curriculum in General Engineering, while the last two years include a number of courses related to glass. Courses offered during the Junior and Senior Years include Engineering Materials, Mineralogy and Crystallography, Fuels and Combustion, Pyrometry, Microscopic and X-ray Studies, Unit Operations of the Glass Plant, Glass Technology, Glass Manufacture and Advance Glass Studies.

KIMBLE GLASS DIVISION APPOINTMENTS

The Kimble Glass Division, Owens-Illinois Glass Company, has announced the appointment of E. B. Dennis, Jr., Edwin J. Rhein and Edward W. Charlesworth as Division Sales Managers.

Mr. Dennis, who becomes Sales Manager of the Container and Accessories Division, joined the Kimble Glass Company in 1933 after having spent seven years as an acoustical engineer with the Johns-Manville Corporation. After serving as New York Branch Manager for the Kimble Glass Company, he became Container Division Sales Manager in 1941.

Mr. Rhein, who has served as Sales Manager of the Scientific Glassware Division of Kimble since 1938, will continue as Sales Manager of the Scientific Division. However, he will have a greatly enlarged sales and service program. He joined Kimble Glass Company in 1929 and has served as Chicago Branch Manager, as Assistant General Sales Manager of the company and as Sales Manager for the Scientific Division.

Mr. Charlesworth, who becomes Sales Manager of the Tube and Rod Division, joined Kimble Glass Company in 1911 and served in Production, Purchasing and Sales. He was later elected a Vice President of Kimble and continued in that capacity until 1947 when the company was acquired by the Owens-Illinois Glass Company.

BOOK REVIEW

Low-Pressure Laminating of Plastics

By J. S. Hicks

The book under discussion is one of a series of five published as a group this year on various phases of the technology of plastics. The author is technical coordinator in plastics for the Owens-Corning Fiberglas Corporation, Toledo, Ohio and was assisted in compiling the book by R. J. Francis, chemical engineer in the product laboratories of the same organization.

The purpose given in the preface, "to outline the several steps necessary to fabricate a laminate, point out sources of materials required, and enumerate some of the pitfalls to be avoided," appears to be accomplished. The book is addressed primarily to the beginner in the field of production of plastics which are reinforced by the use of various laminating media together with resins which cure under low pressures. These media are principally cloths of various fibers, mats, paper, or wood. It is perhaps only natural that Fiberglas as a reinforcing medium should predominate throughout the book and that the majority of the illustrations should portray products and processes employing Fiberglas laminates. Many other materials are cited, of course, throughout.

The eight chapters cover, in order, (1) a general discussion of plastics, laminating pressure ranges, reinforcing agents, post-forming methods and suppliers of laminated flat sheets; (2) the use of materials such as plaster, sheet metal, wood, low-melting alloys, and others in constructing molds, as well as the types of parting agents to be used and mold design factors to be considered; (3) the low-pressure resins which are being used successfully, with a description of several methods of securing proper curing temperatures and pressures, including certain types of molds and processes which have been patented; (4) properties and uses of laminates employing the various reinforcing agents, together with a brief discussion of sandwich type structure and the core materials found therein; (5) a very brief and elementary discussion of the physical properties considered in the testing of laminates; (6) detailed steps in the laminating of three illustrative articles, a tank cover, a boat deck, and a milk bottle carrier, followed by a fairly thorough consideration of the most recent developments in the use of felted fibers or mats in "production line" methods of laminating; (7) procedures to follow in the machining of plastic laminates with reference to methods of joining laminate parts; (8) an analysis of engineering and cost factors from several viewpoints. These are followed by an appendix outlining some very preliminary experiments in laminating and a list of the patents referred to in the text.

The general organization of the book is that of an outlined discussion with extensive references to sources of materials or to additional reading being brought in whenever appropriate. The reading references appear to cover the field reasonably well, although some are distinctly of the "popular" rather than technical variety and duplication of references has been found. The illustrations are copious and for the most part were taken from the publicity files of the Fiberglas Corporation. They do not always distinctly show what is to be illustrated but in general supply information as to processes and products heretofore not generally publicized.

The book should serve as an excellent manual for the person beginning work in the low-pressure laminating of plastics, especially if actual industrial or laboratory experience can accompany its use.

Published by the Reinhold Publishing Corporation, 330 W. 42nd St., New York City, 1947. Pp. 162, 6 x 9 in.; price $4.50.

H. E. Powell

J. E. EAGLE TO HEAD PEMCO COLOR SALES

A recent announcement has been made by Pemco Corporation that J. E. Eagle has been appointed Manager of Color Sales for the company.

Mr. Eagle joined Pemco early in 1946 to organize and manage the company's new Glass Color Division. In his new capacity, he will manage both the Glass Color Division and the Enamel Color Division.

Prior to his association with Pemco, Mr. Eagle was Chief of the Non-Metal Section of the War Production Board. He was associated with the tile industry for eight years while working for the Mosaic Tile Company and the Cambridge Tile Company and for twelve years did sales, development and service work for the Vitro Manufacturing Company.

ANNOUNCEMENT OF URBANA CONFERENCE

Announcement has been made of the Ninth Conference on Glass Problems to be held at the University of Illinois, Urbana, Illinois, Department of Ceramic Engineering, on Thursday and Friday, December 4 and 5, 1947.

Designed to deal primarily with production problems in the glass industry, one full day of the Conference will be devoted to fuel problems and one half day each to raw materials and handling and packaging problems. The complete Conference program will be announced in the Fall.

BALL BROTHERS NAMES EASTERN MANAGER

The appointment of Kenneth C. Frazier of New York to manage eastern division sales has recently been announced by Ball Brothers Company. The appointment is effective immediately. Mr. Frazier will be located at 41 East 42nd Street, New York City.

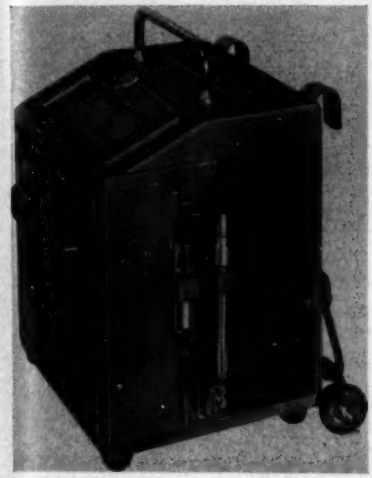
Formerly with the Columbia Chemical Division of Pittsburgh Plate Glass Company, Mr. Frazier joined Ball Brothers earlier this year. He had served as Columbia's eastern district sales manager since 1942. He was also southwestern sales head in Dallas, Texas, for Southern Alkali Corporation from 1931 to 1942. Before that, he was a salesman for the Solvay Process Corporation.

NEW EQUIPMENT AND SUPPLIES

DIRECT-READING pH METER

Cambridge Instrument Company, 3169 Grand Central Terminal, New York 17, N. Y., has announced a new Industrial Model direct-reading pH Meter for measuring acidity and alkalinity.

As a laboratory instrument, the pH meter can be used at a bench or table for tests of small samples. As a port-



able instrument for making spot-checks, its weight of only 10 lbs. and the mounting of the electrode system as an integral part of the meter, make it convenient to carry. As a continuous indicator directly on processing operations, the meter can be suspended over a vat or tank, hung from a rack or mounted on a wall. On such processing applications, it can be used directly in grounded solutions as the glass electrode is completely shielded; extra-length lead wires can be furnished to permit use of electrodes at any desired distance from the meter.

Batteries have been completely eliminated—operation is from any 110-volt 50 or 60 cycle A.C. outlet. A voltage-regulator corrects fluctuations from 100 to 130 volts. High stability has been obtained through improved design of electronic circuit and galvanometer; re-calibration will seldom be needed oftener than once a week. Compensation is automatic for variations from 0 to 100° C. in solution temperature and for changes in room temperature. The clear scale is set at an angle at the top of the metal case so pH values can be read at a glance. Accuracy is .10 pH over the instrument's full range of 0 to 14 pH.

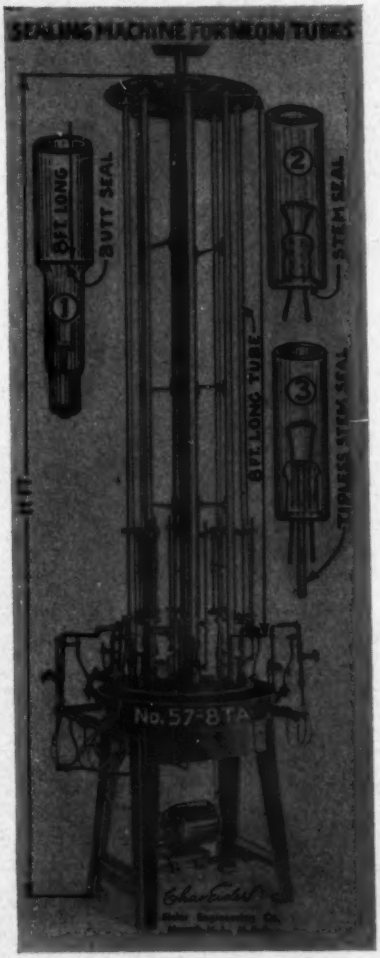
KIRK & BLUM DUST CONTROL UNIT

Kirk & Blum Manufacturing Co., 2804 Spring Grove Avenue, Cincinnati 25, Ohio, has announced the manufacture of a new self-contained dust control unit. The new unit is said to meet the needs of both large and small plants where layouts require the placing of one or more machines in buildings not served by the central dust control system, or in isolated parts of the main plant building.

The unit can be set up anywhere to serve any machine for as brief or as long a period of time as needed. It will handle sawdust and shavings from wood-working machines, grinding, buffing and polishing dirt from metal working machines and all similar dust sources. It features an air volume of 900 CFM at 2″ suction, capacity for four 3″, two 4″ or one 6″ pipe connections, and a four cubic ft. storage compartment, in addition to being semi-automatic in its cleaning operation.

EISLER SEALING MACHINE

Eisler Engineering Co., Inc., Newark 3, New Jersey, announces the development of a new model of an 8-head Sealing Machine adaptable for butt sealing of electrodes to neon tubes, or for sealing-in or tipless stems into fluorescent tubes up to a length of 8 feet.



The machine shown consists of a steel table-structure, carrying the turret with the chucks and the special sealing holders for long tubes. A short sturdy center column is mounted on the table and coupled with a hollow steel shaft set up to a height of more than 8 feet. It is powered by an ¼ h.p. 1725 RPM motor with variable speed pulley.

The flared glass tube of the neon electrode is butt-sealed to the fluorescent tube (see insert #1 in photo) by the action of five fire positions on the machine. In the first, single, and second double-fire, the glass is preheated; in the third, triple crossfire, the glass is made plastic, and in the heat of the next quadruple fire section, the butt sealing is accomplished prompted in this instant by an additional impulse of a push-up arrangement underneath the table.

The last single fire anneals the finished glasswork. The operation of the machine is continuous and fully automatic, requiring only the feeding of the electrode glass holder and of the long neon tube onto the idle loading position and the removal of the finished work from the unloading station.

NEW pH TEST KIT

R. P. Cargille, 118 Liberty Street, New York 6, New York, has announced a new pH Test Kit containing nineteen Hydrion pH Test Papers in eighteen plastic dispensers, all in one convenient case.

This complete assortment covers the full range from pH 0.0 to pH 14.0, and distinct color changes can be obtained within 0.25 pH Unit of almost any point of interest on the pH scale. Eleven of these papers are now released for the first time. The assortment is listed as Hydrion Set H-20; Price $20.00.

CATALOGUES RECEIVED

The O. Hommel Company, 209 Fourth Avenue, Pittsburgh, Pa., has published a new catalogue telling the story of their air brushes.

The catalogue shows illustrations of the many types of air guns available and explains their various specialized uses in the ceramic industry and general application in other industries. The catalogue is said to be a handy reference manual to anyone seeking information on spraying.

The Pyrometer Instrument Company, 103-105 Lafayette Street, New York 13, N. Y., has issued a four-page bulletin, No. 160, illustrating and describing in detail its New Pyro Surface Pyrometer.

The bulletin describes the instrument which is designed especially for the innumerable production and laboratory requirements for a quick and accurate method of determining surface and sub-surface temperatures.

(*Continued from page* 353)

their refractive index with time.

The number of substances which can be evaporated onto a glass surface and which meet the requirements of anti-reflection coatings is small. In order to be optically efficient the refractive index of the salt should be low, which leaves practically only the fluorides. In addition, the deposit should be mechanically strong, resistant to abrasion and insoluble in water. Substances with strong absorption in the visible region are excluded. The only compounds at the present time which are of practical interest are:

CaF_2	$n_d = 1.434$
MgF_2	$n_d = 1.386$
$3NaF \cdot AlF_3$	$n_d = 1.339$
$5NaF \cdot 3AlF_3$	$n_d = 1.345$

The theory of the influence of monolayers of these salts as well as the practical application for decreasing the reflectivity of glass surfaces has been worked out by Strong,[44] and Cartwright and Turner.[59]

From the viewpoint of surface chemistry of glass, another process developed by F. H. Nicoll[60] is of particular interest. The first step of this process consists of the deposition of fluorides and fluorosilicates on the glass surface through its reaction with diluted hydrofluoric acid gas. All silicates are soluble in diluted hydrofluoric acid because of Si-F bonds replacing the Si-O bonds and thus destroying the glass structure. The final reaction products are SiF_4, H_2SiF_6 and the fluorides and silicofluorides of the basic constituents.

If the amount of HF available for the reaction is not sufficient to change the glass completely into fluorides and silicofluorides, the attack proceeds in several steps. The first step is the replacement of OH^- groups by F^-. In the next chapter the surface properties of such a glass shall be discussed in more detail. In the second step, those O^{2-} ions are replaced by 2 F^- ions which are situated between an Si^{4+} and a network-modifier, leaving the oxygens in the Si-O-Si bridges still intact. Under carefully controlled conditions, the reaction of HF with a glass surface can be arrested at this step and complete solution of the glass can be avoided. Up until this reaction step, the HF attack is allowed to proceed toward the interior. The reaction products, the fluorides and silicofluorides, of the basic glass constituents are soluble in water and can be removed by washing. That leaves a "skeletonized" glass surface whose refractive index may be as low as 1.28. The progress of this complicated reaction can be followed by interference colors; it depends on time, temperature, composition of the glass, water vapor pressure and HF concentration in the vapor phase.

In the first section of this chapter, two methods of precipitating silica from solutions were mentioned. We have learned that the reactions of a glass surface with HF under controlled conditions may also lead to the formation of a silica skeleton having a low refractive index. In the following chapter we shall learn that siliceous films can form as a result of acid attack. In addition to these methods, another unusual process should be mentioned which also leads to the deposition of a silica film. This film is so dense that it can be used to protect unstable surfaces. The process is based on the discovery by E. Zintl[61] that in vacuo at 1100°C., elemental silicon may react with silica to form the volatile but rather unstable silicon monoxide, SiO.

$$Si + SiO_2 = 2\,SiO \text{ (reversible)}$$

The silicon monoxide has a tendency to decompose to form a mixture of Si and SiO_2.

N. W. Scott[62] recommended this process for the protection of front surface mirrors of aluminum metals because it imparts to these mirrors good abrasion, corrosion and reflection qualities. Aluminum mirrors are used because of their high reflectivity over a wide spectral range. They have a finer grain and a smoother surface than silver coatings but have to be protected from atmospheric attack. Direct evaporation of silica yields loose layers. Formation of Al-O-Si bonds in this temperature range is rare because of the high activation energy involved. N. W. Scott, therefore, used the evaporation of silicon monoxide which, due to its chemical reactivity, has a better chance to form Al-O-Si bonds and to adhere more strongly.

The visual reflectivity of aluminum mirrors protected with an optimum thickness (about 1200 A) of SiO is about 90%, that is 1% lower than the unprotected aluminum surface. In the infrared from 2μ to 8μ these layers do not show any appreciable absorption. In the ultraviolet, the SiO layer shows absorption which depends very much upon the evaporation conditions. This absorption is probably due to the presence of elemental silicon and can be decreased by an oxidizing treatment. The abrasion resistance of the mirrors is tested by means of a steel ball covered with linen, loaded with a 500-g weight and subjected to a reciprocating motion. An SiO protected mirror withstands motion of more than 1000 cycles without damage, whereas an unprotected aluminum surface shows scratching after one cycle. The SiO protected mirror is unaffected by prolonged heating at 450°C. and after one hour of immersion in 10% NaOH solution the reflectivity remains practically unchanged.

This process deserves our attention because it may be developed further by combining the SiO_2 with other volatile oxides, such as B_2O_3 and basic constituents. It leads to a new possibility for the formation of a glass film at low temperature comparable to the enamel on metals.

7. *Hydrolysis of the glass surface and reactions of the silica gel with aqueous solutions and vapors.*

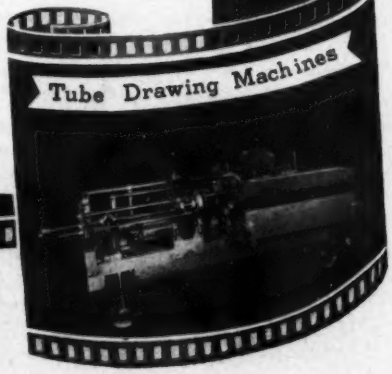
A) *Wetability of the glass surface.* Silicate glasses melted under technical conditions contain a small but noticeable amount of water which is in equilibrium with the furnace atmosphere. This water participates in the glass structure in the form of OH^- groups attached to an occasional silicon ion. The monovalent OH^-, taking the place of divalent O^{2-}, interrupts the continuity of the SiO_4 network and thus lowers the viscosity of the melt. Reactions between silica and other oxides are therefore greatly accelerated by water vapor. The structure of glasses containing water can be compared, to a certain extent, with those containing fluorides because the crystal chemical properties of OH^- and F^- are nearly identical: both have the same size and charge, and similar polarizabilities. Isomorphous replacement of OH^- for F^- is found in many minerals (apatite, topaz, mica). Water-

(*Continued on page* 372)

World-foremost ...IN GLASS PLANT EQUIPMENT

Glass Melting Furnaces
Window Glass Tanks
Amco Lehrs
Lehr Loaders
Fuel Oil Systems
Plate Glass Furnaces
Gas Producer Systems
Recuperative Pot Furnaces
Continuous Grinding and Polishing Equipment
Batch and Material Handling and Storage Equipment
Sheet and Plate Glass Lehrs

Rolled Sheet and Plate Glass Plants
Complete Bottle and Tableware Plants
Complete Window Glass Plants
Modern Factory Buildings
Appraisals



AMSLER MORTON CORPORATION
CHAMBER OF COMMERCE BLDG., PITTSBURGH 19, PA.

SURFACE CHEMISTRY OF GLASS . . .

(*Continued from page* 370)

containing glasses may also be called "hydrogen glasses" because their structure can be derived from a sodium glass where an occasional Na^+ of the glass is replaced by an H^+ ion.

A clean dry glass surface shortly after fracture consists of hydrogen glass because there is sufficient water in the atmosphere to be attracted and used to saturate the valence forces which became available through the fracture.

The chemical properties of these OH^- groups determine the behavior of the glass surface at room temperature. Hydroxy groups or hydrogen ions are able to associate with other groups of the same type under formation of "hydrogen bond." The character of these hydrogen bonds, especially their low activation energy, is responsible for many phenomena (usually referred to as molecular associations) affecting the physical properties of "associated liquids," such as water, glycerol or hydrofluoric acid. The low activation energy makes it possible for these bonds to form and to break frequently even at room temperature. Due to the formation of hydrogen bonds, a glass is completely wet by water, alcohol, or sulfuric acid and other liquids having OH^- groups. The role which the OH groups play in the wetting of glass can be convincingly demonstrated by a simple experiment. Concentrated sulfuric acid to which a trace of potassium dichromate has been added is heated in a test tube. The chromate oxidizes organic impurities and thus produces a clean glass surface whose structure is schematically represented in Fig. 6a. Fig. 6b represents the structure of the wet glass surface where part of the OH groups are dissociated. Sulfuric acid molecules also can be bound to this surface by the hydrogen bonds indicated by the dotted lines. Adding a trace of a fluoride to the sulfuric acid causes the OH^- groups to be replaced by F^- ions according to the equation:

$$\geqslant Si\text{-}OH + HF = \geqslant Si\text{-}F + H_2O$$

Because of the dehydrating effect of the concentrated sulfuric acid, this reaction will proceed to completion. After a few seconds, the inner surface of the test tube is depleted of OH groups and covered with fluorine ions. The change in structure is schematically expressed by Fig. 6c. With the OH groups missing, the surface now lacks the possibility of forming hydrogen bonds and, as a result, it loses its wetability by sulfuric acid. The sulfuric acid forms little droplets on the glass surface and behaves like water in a greasy glass container. The minor substitution of F^- for OH^- has completely changed the interfacial tension between glass and sulfuric acid, because the fluorine ion under the strongly polarizing influence of the silicon cannot exert a force upon the H_2SO_4 molecules which is sufficiently strong to produce wetting. The silicon fluoride is a covalent compound. In the absence of water the silicon fluoride layer is stable and, if the glass tube with the sulfuric acid is sealed, the inner surface retains its repellency indefinitely. However, in the presence of water, hydrolysis takes place and the former OH groups are restored. Silicon fluoride reacts with water to form silicic acid and hydrofluoric acid. Such a glass surface is completely wet by water, that means, it has a contact angle of zero. In contact with water, a certain amount of dissociation takes place, leading to the formation of positively charged H^+ or H_3O^+ (hydroxonium) ions and a negatively charged surface film. (See Fig. 6b.) With prolonged exposure to water or diluted acids, this hydrolysis is not restricted to a monomolecular layer but slowly proceeds into the interior. By gradually removing the cations, Na^+ and Ca^{2+}, and replacing them by an equivalent number of H^+ a film of silica gel is formed.

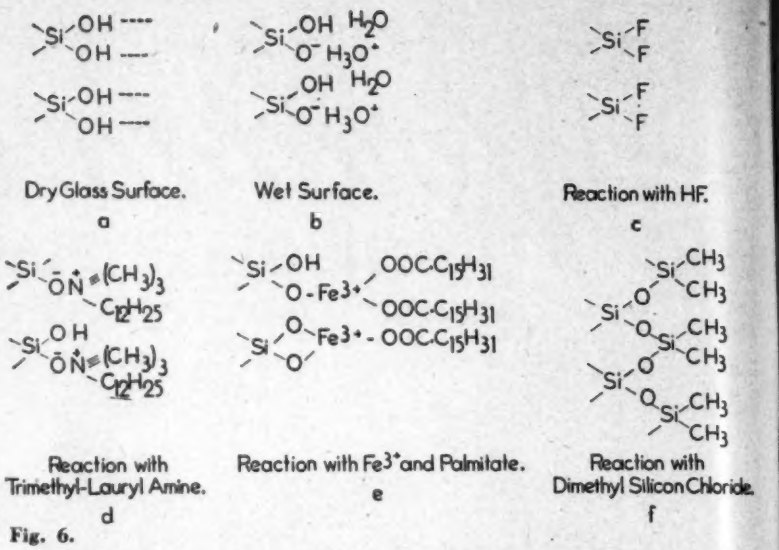


Fig. 6.

Before further discussing the process of weathering or corrosion of the glass surface, let us examine which methods exist for making a glass surface water repellent so that a finite contact angle is established between glass, water and air.

In a previous chapter dealing with the contact angle (captive bubble method) as a means for determining the adsorption of cations on the glass surface, it was stated molecule whose hydrogen atoms have been replaced by that the adsorption of an organic amine (an ammonia hydrocarbon radicals) produces water repellency. The trimethyl lauryl ammonium ion, for example, has the structural formula:

$$\begin{array}{l} CH_3 \\ CH_3N^+ \\ CH_3 \end{array}$$

$$CH_3 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2$$

which shows the long tail-like hydrocarbon group responsible for the paraffin-like properties. The fact that the nitrogen has a positive charge accounts for the strong adsorption of this group at the surface of the negatively charged silica gel. The result is schematically represented in Fig. 6d. Water repellency is produced as a result of the lauryl groups extending into space.

If we treat a clean wet glass surface, such as described in Fig. 6b, with a solution of soap, the glass does not become water repellent despite the soap being a mixture

(*Continued on page* 374)

TIP for TABLEWARE MANUFACTURERS

If you use 30 lbs. of Kryolith per 1000 lbs. of sand, you get the equivalent of:

22.7 lbs. Soda Ash* **16.3 lbs. Fluorine***

11 lbs. Aluminum Hydrate

*Because fluorine reduces the softening point of glass, you can reduce the soda still further without increasing the cryolite. In the case above, for example, 30 lbs. of Kryolith actually replaces 37 lbs. of soda ash, instead of 22.7 lbs.

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SURFACE CHEMISTRY OF GLASS . . .
(*Continued from page* 372)

of salts of fatty acids, such as palmitic acid:

$$CH_3 \cdot (CH_2)_{14} \cdot COO^- H^+$$

or stearic acid:

$$CH_3 \cdot (CH_2)_{16} \cdot COO^- H^+$$

These organic compounds also have long hydrocarbon chains but their ions are negatively charged and thus are repelled from, and not adsorbed at, the negatively charged silica gel. However, if the glass surface is "contaminated" by cations of high valency, for example, Fe^{3+}, Al^{3+} or Zr^{4+}, its negative charge may be overcompensated by these positive ions and, as a result, the anions of the fatty acids are strongly adsorbed and impart hydrophobicity (water repellency) to the glass.

The change of the negatively charged glass surface into a positively charged surface through the adsorption of ferric ions corresponds chemically to the surface changing from a weak acid (silicic acid) to a weak base (ferric hydroxide). The acid is able to react with basic constituents under formation of a salt. The basic surface combines with acidic constituents, such as the fatty acids. Using a soap as an indicator, the "hydrophobicity test" provides a rapid method for detecting contaminations of the glass surface with polyvalent cations.

This test is carried out as follows: The glass is exposed to the solution or the vapor of a metal halide for a given length of time. Washing with distilled water and diluted ammonia removes excess salt. The glass is dipped into a soap solution and again washed with water. If the first treatment with $AlCl_3$ or $FeCl_3$ solution produces a molecular layer of Al^{3+} or Fe^{3+} adsorbed in the silica gel, the glass shows a fatty appearance after dipping into the soap solution and removing the excess soap with water. Fig. 6e presents a picture of a glass surface contaminated by ferric ions after exposure to an aqueous solution of sodium palmitate.

This experiment reproduces in a few minutes what happens to a glass surface during its normal life. Organic molecules, such as fatty acids, are present in the atmosphere, in dust and even in the clean handkerchiefs which we use to polish and "clean" a glass. As a result, the normal surface of a window or a mirror has a finite contact angle with water and is not completely wet. Exhaling against a cold glass, as a rule, does not produce uniform layers of water but causes the moisture to condense in little droplets. This phenomenon was first studied and explained by Lord Rayleigh,[63] who described it as follows:

"The manner in which aqueous vapour condenses upon ordinarily clean surfaces of glass or metal is familiar to all. Examination with a magnifier shows that the condensed water is in the form of small lenses, often in pretty close juxtaposition. The number and thickness of these lenses depend upon the cleanness of the glass and the amount of water deposited.

"Information as to the character of the deposit is obtained by looking through it at a candle flame. The diameter of the halo measures the angle at which the drops meet the glass, an angle which diminishes as the dew evaporates. That the flame is seen at all in good definition is a proof that some of the glass is uncovered. Even when both sides of a plate are dewed the flame is still seen distinctly though with much diminished intensity.

"The process of formation may be followed to some extent under the microscope, the breath being led through a tube. The first deposit occurs very suddenly. As the condensation progresses, the drops grow, and many of the smaller ones coalesce. During evaporation there are two sorts of behaviour. Sometimes the boundaries of the drops contract, leaving the glass bare. In other cases the boundary of a drop remains fixed, while the thickness of the lens diminishes until all that remains is a thin lamina. Several successive formations of dew will often take place in what seems to be precisely the same pattern, showing that the local conditions which determine the situation of the drops have a certain degree of permanence.

"An interesting and easy experiment has been described by Aitken. Clean a glass plate in the usual way until the breath deposits equally.

"If we now pass over this clean surface the point of a blow-pipe flame, using a very small jet, and passing it over the glass with sufficient quickness to prevent the sudden heating breaking it; and if we now breathe on the glass after it is cold, we shall find the track of the flame clearly marked. While most of the surface looks white by the light reflected from the deposited moisture, the track of the flame is quite black; not a ray of light is scattered by it. It looks as if there were no moisture condensed on that part of the plate, as it seems unchanged; but if it be closely examined by a lens, it will be seen to be quite wet. But the water is so evenly distributed, that it forms a thin film, in which, with proper lighting and the aid of a lens, a display of interference colours may be seen as the film dries and thins away.

"Another way of studying the change produced on the surface of the glass by the action of the flame is to take the plate, as above described, after a line has been drawn over it with the blow-pipe jet, and when cold let a drop of water fall on any part of it where it showed white when breathed on. Now tilt the plate to make the drop flow, and note the resistance to its flow, and how it draws itself up in the rear, leaving the plate dry. When, however, the moving drop comes to the part acted on by the flame, all resistance to flow ceases, and the drop rapidly spreads itself over the whole track, and shows a decided disinclination to leave it.

"The impression thus produced lasts for some days or weeks, with diminishing distinctness. A permanent record may be obtained by the deposit of a very thin coat of silver by the usual chemical method. The silver attaches itself by preference to the track of the flame, and especially to the "edges" of the track, where presumably the combustion is most intense."

Aitken attributed the effect of the flame on the wetability of the glass to fine dust deposited from the flame. Lord Rayleigh did not share this view but recognized that the phenomenon must be connected with the absorption of greasy matter from the atmosphere. He writes:

"It seems to me that we must appeal to varying degrees of cleanliness for the explanation, cleanliness meaning mainly freedom from grease. And one of the first things is to disabuse our minds of the idea that anything wiped with an ordinary cloth can possibly be clean.

(*Continued on page* 376)

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SURFACE CHEMISTRY OF GLASS . . .
(*Continued from page* 374)

This subject was ably treated many years ago by Quincke who, however, seems to have remained in doubt whether a film of air might not give rise to the same effects as a film of grease. Quincke investigated the maximum edge-angle. With alcohol and petroleum there was no difficulty in reducing the maximum angle to zero. With water on glass the angle could be made small but increased as time elapsed after cleaning."

Lord Rayleigh, recognized that the action of the flame could not be caused by its mere heat when he wrote: ". . . . and yet mere heat is not very effective. I was unable to obtain a good result by heating the back of a thin glass in a Bunsen flame."

Today it is an established fact that this effect of the flame is due to the emission of electrically charged particles. Bombardment with electrons and exposure of a glass to glow discharge are now applied for cleaning the glass prior to the deposition of films in the manufacture of optical elements.

A recent paper by E. C. Marboe and W. A. Weyl[64] described in more detail conditions which produce permanent hydrophobicity of a glass surface. A short contact with metallic iron can provide sufficient ferric ions in the glass surface to cause greasy constituents to adhere firmly. During the manufacture of optical elements, plate glass and mirrors, the wet glass should be guarded against contact with iron because a galvanic action causes the glass surface to change its properties around the point of contact. The iron sends positively-charged ferrous ions into solutions and thus assumes a negative charge. This negative charge is dissipated through the conducting layer of the glass surface, which in turn establishes a negatively charged area. This area attracts the positively charged iron ions and covers itself with ferric hydroxide.

A short contact between iron and a wet glass surface does not produce a visible mark. Exhaling against the dry surface, however, reveals that ferric ions are present in sufficient quantities to make fatty acids adhere more strongly than at the rest of the surface. This in turn changes the contact angle of the water droplets. Deliberate contamination of a certain area, for example, bringing a heavy metal ion (silver or tin compounds) onto the glass surface by means of a rubber stamp is used for producing an invisible mark on glass (breath mark).

A prolonged contact with iron builds up a layer of ferric hydroxide thick enough to produce interference colors (silvery speck) and finally the brown color of the ferric hydroxide.

The surface conductivity of the glass is not necessarily based on alkali alone but probably is due to hydrogen or hydroxonium ions. No principle difference was observed between the staining of a sodalime glass, a low alkali borosilicate glass, a dealkalized glass and vitreous silica.

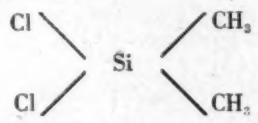
The role which the electric potential of the glass surface plays in this staining process could be domonstrated by bringing the glass in contact with platinum wire connected to a low voltage battery. Only in the zone where the glass contacts the negative pole will the stain be developed.

A clean glass surface is hydrophylic and retains this property after having been emersed in a soap solution. A glass whose surface area has been contaminated with polyvalent cations, such as Fe^{3+} and Al^{3+}, prior to its treatment with soap becomes hydrophobic. These facts are important for glass surfaces which have to be treated chemically either for silvering or for leaching with acids. Uniform reactions can be expected only if the total glass surface is hydrophylic. Hydrophobic areas delay the replacement of sodium ions by silver ions which is the first step in silvering, or by hydrogen ions in the process of acid leaching. F. L. Jones and H. J. Homer[65] in their description of a chemical method for decreasing surface reflectivity, emphasized the importance of a fresh and uniformly clean glass surface when they wrote.

"The initial rate of reaction between a clean glass surface and an acid solution is governed by the composition of the glass, the composition of the solution and the temperature. Even with these variables under control, it is seldom possible to treat a lens taken directly from stock and obtain a film of uniform thickness on the two surfaces. In some cases an assortment of mysterious marks and fingerprints appear in different colors. This variation is not found with surfaces treated immediately after they are removed from the polishing machine."

Spots on an optical surface which had become hydrophobic through contamination will show this defect after acid leaching. Its interference color will indicate that the contaminated area is less thick than the surrounding area.

For certain purposes, however, hydrophobicity of the glass surface is desirable. The surface electric resistance of a glass or a ceramic insulator can be increased considerably after the surface of this insulator is made water repellent. For this purpose W. I. Patnode[66] developed a treatment with organo-silicon halides, for example, dimethyl silicon chloride.



In contact with the surface of glass or any ceramic material the vapor of this compound enters a chemical reaction with the OH groups under liberation of HCl. Under ideal conditions the glass surface is modified as pictured in Fig. 6f. The lack of OH^- groups prevents such a modified glass surface from being wet by water. The nature of the glass surface prior to the treatment is important for the stability and efficiency of the film. A certain amount of water is essential for the reaction. However, glass surfaces which had been hydrolyzed for too long and, as a result, are covered with a film of hydrogen glass or hydrated silica gel, cannot obtain the full benefit of this treatment. They will assume water repellency, but underneath a molecular layer of the organo-silicon there still exists a conducting layer of hydrogen glass.

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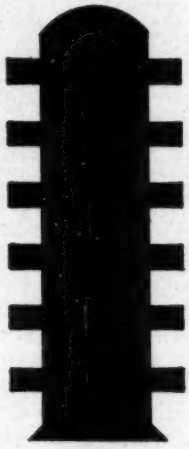
(*Continued on page* 382)

These are the shapes of things to come



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THERMOCOUPLE EXTENSION LEADWIRES . . .

(*Continued from page* 355)

ments are such that each particular type of thermocouple will not be used subject to all conditions of exposure. The following list shows the types of insulations available, together with the general conditions under which they should be used:

Polyvinyl Thermoplastic—General purpose insulation for use in temperature conditions under 140° F. This insulation is greatly resistant to deterioration and moisture.

Felted, wax-impregnated, asbestos—High temperature, flame and moisture-resistant insulation. Used generally where the temperature ranges from 140° F. to 400° F. The asbestos, impregnated with a flame and moisture-proof wax, forms an insulation suitable for installations wherein flames, steam, and high temperatures are encountered. It also has considerable resistance to moisture.

Rubber—Flexible, moisture-resistant insulation. Generally used where flexibility is the paramount factor, such as for portable use, and where the temperature does not exceed 110° F.

The proper installation of the extension leadwires is of no less importance than the wire itself in the attainment of accurate pyrometer readings over long periods of service. Many failures and inaccuracies in pyrometer systems have been the result of poor electrical connections and grounded wiring.

There are but a few rules to be followed in making a proper installation. Whenever possible, the leadwires should be run in conduit to protect them against the possibility of mechanical injury. All necessary *splices* must be *soldered, wrapped first with rubber tape,* and *then with friction tape.* It is extremely important that the polarity markings throughout the wiring between the thermocouple and the indicating instrument be followed and that they be connected in the proper polarity at all terminals. For example: The red negative lead, common to most extension leadwires, must first be connected to the negative terminal on the thermocouple; the red colored conductor must then be spliced only to a red colored conductor throughout the wiring to the instrument at which point it must be connected to the negative terminal of the indicating instrument. The observance of these simple rules for the wiring of the pyrometer system not only assures accurate results, but dependable service.

It has been the intention of this article to emphasize the extreme importance of the extension leadwires in any pyrometer installation. The use of improper leadwire or the possibility of improperly installed leadwires impairs both the accuracy of the temperature indication and the control of the process variable. The effect of wide variations in ambient temperature becomes a serious detriment in obtaining accurate indications unless the proper extension leadwire is used. Careless wiring, poorly soldered or unsoldered splices, carelessly taped splices or mechanical abrasion of the leadwire insulation can result in either complete or partial failure of the pyrometer system. However, the selection of the proper kind of leadwire, and careful adherence to the few simple rules necessary for a good extension leadwire wiring job, will result in not only accurate measurement and control, but a saving in maintenance and repair.

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This "TR" series is but one of a group. Others include

- "TN" for light bulbs
- "TB" for Bottles
- "TU" for lighting units

"TR" also used for Dinnerware-Tumblers

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GLASS COLOR DIVISION

INVENTIONS AND INVENTORS . . .

(*Continued from page* 362)

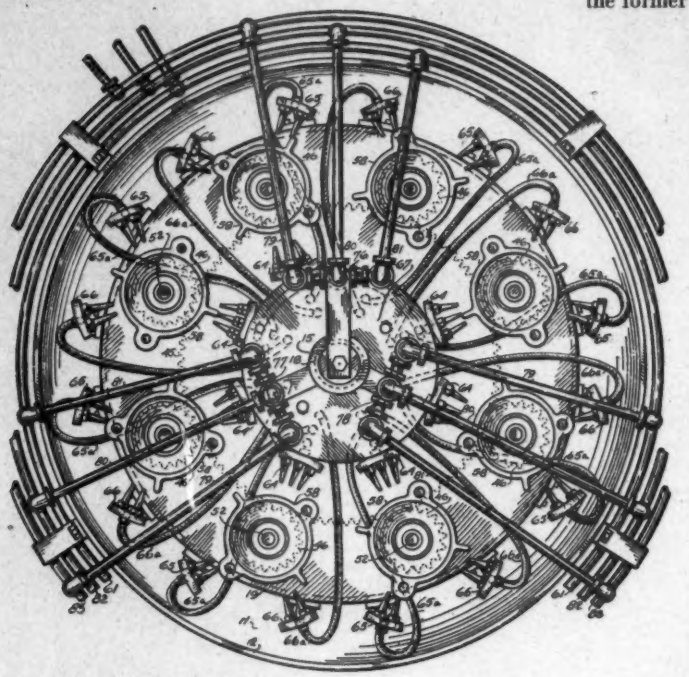

Fig. 6. Eisler Bulb Sealing Machine.

Spohr, June 2, 1942; and 1,811,201, Kleinberg, June 23, 1931.

Eisler Bulb Sealing Machine. Fig. 6. Patent No. 2,421,929. This patent is one of a series issued to Charles Eisler of the Eisler Engineering Company of Newark, N. J. The machine is of the turret type in which the table moves continuously instead of step-by-step. This prevents the bulbs or working parts from being jarred out of place by the stopping and starting of the table. Many parts of the machine are of well known construction but certain features are improvements over the former construction.

Fig. 6 is a plan view of one of the new sealing machines having eight heads. A base 11 provides a circular through 12 to receive the glass cut from the necks of the bulbs. A spider 19 is mounted for rotation about a central post 15. A drive mechanism is provided to rotate the spider continuously which does away with a Geneva drive or cam mechanism to give intermittent motion. This makes it necessary that the working parts such as burners be carried along with the spider. Each head is rotated by a slip gear 16 and sealing rods 52 pass through the center of each gear. A bulb support 68 of the usual type is provided for each head.

In order that the rotation of the heads may be stopped to allow the operator to remove the sealed bulb and insert a new bulb, pins are provided at these two stations which hold the heads from turning and at that time the frictionally driven gear 46 slips with respect to the drive mechanism.

The bulbs are subjected to the usual process of preheating, hot flame and annealing and of course each treatment requires a different temperature. To this end three different sets of burners are provided for each head, these being shown at 64, 65 and 66. The fuel supply is delivered by pipes which are opened and closed by the usual mechanism. The stop and start control of continuously moving heads is a decided improvement over the old machines.

The following references are of record in the file of this patent: United States patents: 1,577,536, Parker et al., Mar. 23, 1926; 2,050,088, Dichter, Aug. 4, 1936; and 1,585,913, Higgins, May 25, 1926.

PENNSALT PLANS $7,500,000 EXPANSION PROGRAM

Tentative plans for an expansion program costing approximately $7,500,000 were outlined in a recent proxy statement mailed to stockholders by The Pennsylvania Salt Manufacturing Company.

Stockholders are being asked to vote, at a special meeting, on a proposed increase of authorized stock of the Company from 1,000,000 shares of capital stock of a par value of $10 a share to 1,650,000 shares to be divided into two classes consisting of 150,000 shares of preferred stock with a par value of $100 a share and 1,500,000 shares of common stock with a par value of $10 each. At present there are 750,000 of the 1,000,000 shares of capital stock outstanding.

If the proposed plan is adopted, all the shares of preferred stock and such unissued shares of common stock as are not reserved for conversion of preferred stock will be available for sale by action of the Board of Directors without further vote of the common stockholders.

Subject to approval of the plan and business conditions, the Directors now are considering the issuance of a first series of 50,000 shares ($5,000,000 par value) of new preferred stock during the coming summer. These shares would be offered to stockholders for subscription.

DREXEL INSTITUTE AWARDS HONORARY DEGREE TO BROWN

At the recent commencement exercises of Drexel Institute of Technology, Richard P. Brown, Chairman of the Board of the Brown Instrument Company, was awarded the honorary degree of Doctor of Engineering. The honor was conferred by Dr. James Creese, President of the Institute.

At the exercises, Mr. Brown presented a talk in which he urged the 418 members of the graduating class to "make good citizenship your avocation" and warned them not to become so absorbed in professional work that they neglected their civic duties.

• Charles B. Rairdon, Assistant Treasurer and General Credit Manager of Owens-Illinois Glass Company, has been elected President of the National Association of Credit Men at the organization's Golden Anniversary Conference in New York recently.

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SURFACE CHEMISTRY OF GLASS . . .

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CORNING ANNOUNCES NEW PHOTOSENSITIVE GLASS

Corning Glass Works has announced a new glass which, through prescribed use of ultraviolet light and heat, can receive permanent colored photographic prints with three dimensional effect. Named photosensitive glass, one of its outstanding characteristics, from a practical standpoint, is the ageless quality of its photographic reproductions which will not fade and are safe from any damage except shattering the glass. This durability results from the fact that the print is inside the glass and often permeates the whole piece.

To reproduce a picture, a negative is placed on the glass (originally crystal clear) and momentarily exposed to ultraviolet light from any of several sources, including sunlight, sunlamp or arc light. Following removal of the negative, the photograph is developed by raising the temperature of the glass to 1000°F.

The secret of this new photographic medium lies in the mixing of invisible submicroscopic metallic particles in the glass. The ultraviolet light precipitates these particles, making them come out of solution and assume color.

The possible color combinations are contingent on the type of ingredients in the glass and the shade or depth of the color is determined by the length of exposure. One glass will reproduce in brilliant red. Another permits pictures in blue, purple, ruby or orange, while a third prints in yellow and brown. The shade of color is determined by length of exposure. With one glass, exposure for a couple of minutes will make the entire picture purple. To make parts of it red, the exposure is continued longer, with the other portions of the negative being masked off.

The three dimensional effect achieved is due to the fact that shadowed areas penetrate farther into the glass than highlight areas. Unusual lighting effects can also be obtained by placing a light behind the glass.

Sensitive only to ultraviolet light, the glass does not have to be handled with the same care required by photographic paper. In printing, black tape is used to mask off sections of the glass not covered by the negative and the process can be carried out in room light.

In order for the glass to change appearance after it has received a print, it must again be subjected to 1000°F.

The uses of this medium potentially are many, according to Corning. Physically, it may be tailor-made for almost any purpose and tempered to the desired strength. Reproduction of extremely fine detail is possible due to the lack of "grain" in the design, due in turn to the smallness of the particles making up the picture (they are smaller than the silver grains in photographic emulsions).

Corning has also developed photosensitive opal glasses whose myriad microscopic transparent particles scatter light in different directions. Colors possible in this medium are white, red, blue, yellow, or brown and combinations of these colors. The opal and transparent glasses can be combined to make designs side by side or superimposed so that the opalescent glass forms a background for a transparent colored surface image.

Following are some specific uses for photosensitive glass: decorated glassware (tableware, goblets, vases), instrument dials, portrait photographs, scenic photographs, church window photo-murals, decorative tile, costume jewelry (miniature portraits, signet rings, religious emblems), illuminated advertising displays, permanent records in microfile print and lantern slides.

KIMBLE GLASS APPOINTS DIVISION SALES MANAGER

R. W. Rogers, former Sales Manager of the Industrial Glassware Division of Libbey Glass, has been named Sales Manager of the Industrial and Electronics Division of Kimble Glass Company, according to an announcement. Mr. Rogers' appointment is made as a part of the integration of Kimble Glass as a division of the Owens-Illinois Glass Company.

Mr. Rogers has been in charge of sales of industrial glassware for the Libbey Glass Division since 1942 when he was placed in charge of special development of glass for war purposes.

Transfer of sales activities of the Industrial and Electronics Division from Libbey to Kimble becomes effective immediately. The manufacturing operation will be transferred at a later date.

PENNSALT NAMES ASSISTANT VICE PRESIDENT

Pennsylvania Salt Manufacturing Company has announced the appointment of William P. Drake, Manager of Sales of the Special Chemicals Division, as Assistant Vice President. Mr. Drake was appointed to assist George B. Beitzel in planning for and executing policies of Pennsalt's expanding sales force and in organizing sales activities.

Mr. Drake joined the company in 1934 and after two years with various Pennsalt plants, joined the sales organization. In 1939, he was made Manager of Sales of the Pennsalt Cleaners Division and in 1943 became Manager of Sales of the Special Chemicals Division.

G.E. ANNOUNCES PYRANOL CAPACITORS

Power-factor capacitors using cast glass bushings with integral hardware that permits a permanent hermetically-sealed unit have been announced by the Transformer Division of the General Electric Company.

The bushings are made of exceptionally stable, low-expansion glass in which are cast metal inserts of a special nickel-steel alloy. The thermal expansion characteristics of the alloy are coordinated with those of the glass. A metal mounting flange cap is fused directly to the glass and the flange is in turn welded and soldered to the capacitor case, forming a hermetic seal that is permanently moisture-tight.

According to G-E engineers, these glass bushings are practically unaffected by weathering, micro-organisms and thermal shock. When excess potential of 60 cycles or impulses are applied, the bushings will flash over externally rather than puncture or shatter, even though external creepage and strike values are large. The bushings are equipped with a split-type solderless connector, assembled after completion of the capacitor.

MINNEAPOLIS-HONEYWELL ANNOUNCES MEXICAN SUBSIDIARY

Minneapolis-Honeywell Regulator Company has formed a subsidiary company in Mexico, according to a recent announcement.

Marking the sixth foreign subsidiary organized by Honeywell, the new firm has been named Honeywell-Brown, S.A. All legal formalities have been completed. and personnel engaged. Headquarters of the new company have been established in Mexico City.

Virgil H. Hiermeier has been named manager of the Mexican company.

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• In natural surface lake deposits located in Wyoming, just off Highway 287, midway between Casper and Rawlins; has never been accurately surveyed; high spot estimates indicate at least 500,000 tons of sulphate and 28,000 tons of carbonate waiting for development; any reasonable offer, preferably on royalty basis, will be considered; inquiries for further detail invited.

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FOR SALE

GLASS PLANT, CHICAGO HEIGHTS, ILLINOIS

By order of the United States District Court for the Northern District of Ohio, Western Division, Owens-Illinois Glass Company offers for sale as a unit all real estate, buildings, machinery, production equipment (not including molds), tanks and furnaces (except experimental machinery and furnaces) located at Chicago Heights, Illinois, and which were a part of the assets acquired by Owens-Illinois Glass Company from Kimble Glass Company on July 1, 1946.

In accordance with the order of the Court such property is offered for sale for cash to any purchaser approved by said Court, subject to prior sale, at the fair market value of said property as a glassware manufacturing plant, as determined by an appraisal made by The Lloyd-Thomas Company, which said appraisal has been duly filed with the Clerk of said Court at Toledo, Ohio., where it may be inspected. Additions and improvements made to the property described above since July 1, 1946, and prior to consummation of sale are not included in the appraised value aforesaid but are offered for sale as a part of the unit for an additional consideration equal to the cost thereof to Owens-Illinois Glass Company.

In connection with the sale of the property and additions and improvements thereto above described, Owens-Illinois Glass Company will assign or cause to be assigned to the purchaser thereof for the consideration hereinafter set forth, all its rights in and to the following machinery and equipment leased from Hartford-Empire Company situate on said premises on July 1, 1946, to-wit:

4—4 head I S machines with feeders, revolving tube drives and motors, and variable speed drives and motors

1—5 head I S machine with same

2—36" x 74' lehrs, gas fired with top vertical discharge, motor driven steel plate exhaust fan, and all regular equipment

The consideration to be paid by the purchaser to Owens-Illinois Glass Company for the assignment of its rights in the leased machinery aforesaid shall be cash in such an amount as will reimburse Owens-Illinois Glass Company for a fair proportion of any and all payments made in connection with said leased machinery by Kimble Glass Company or Owens-Illinois Glass Company which may be considered as costs of installation, advance payments for minimum annual royalties, license fees, parts, insurance and taxes.

In the event of such sale, possession will be delivered not later than six months after the consummation of such sale to a purchaser approved by the said Court.

Address all inquiries to

Owens-Illinois Glass Company
Attention: F. G. Morfoot
P. O. Box 1035, Toledo 1, Ohio

INCREASED MOLD LIFE . . .
(*Continued from page* 357)

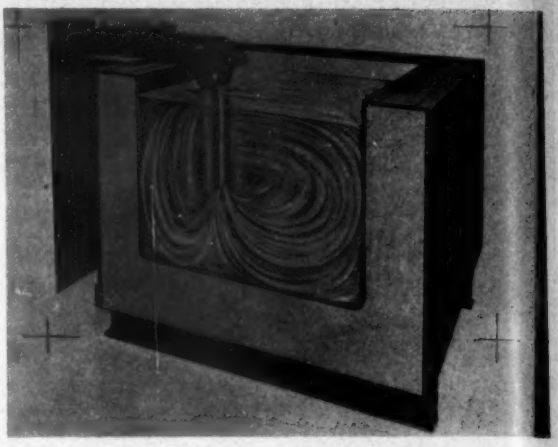

Fig. 4.

ates a strong magnetic field and sets up electrodynamic forces so much more powerful than the thermal forces that the liquid column between the electrodes is caused to move *downward*, setting up a vigorous, automatic stirring action in a downward direction. Because of this stirring action, independent of any temperature differences within the bath, it is possible to hold the temperature in every part of the bath to within 5°F. of the control setting.

Temperature is automatically controlled by a thermocouple and relays which release power into the bath instantaneously when more heat is needed. There is no time lag such as would occur if heat from an external source had to be forced through thick pot walls before reaching the bath. Therefore, the bath recovers temperature very rapidly when a large charge is placed in it and more work can be processed in a given time.

The furnace is very compact and need be only large enough to actually receive the largest mold or part which will be processed in it. Together with the needed quench and dip tanks, it can be located in any part of the plant most convenient for handling the molds. The walls of the furnace are heavily insulated and a rolling, insulated cover is provided to retain heat during idle periods.

1946 BOOK OF A.S.T.M. STANDARDS

The 1946 Book of A.S.T.M. Standards, recently issued, contains five parts instead of the former three volumes. The book contains more than 1400 standards, specifications, tests and definitions for a wide range of material. It carries the A.S.T.M. specifications and tests in their latest approved form.

The five parts into which the book is divided are Ferrous Metals, Non-Ferrous Metals, Nonmetallic Materials (Constructional), Nonmetallic Materials (Coal and Coke, Petroleum Products, Aromatic Hydrocarbons, Soaps, Waters, Textiles, Gaseous Fuels) and Nonmetallic Materials (Electrical Insulating Materials, Plastics, Rubber, Paper, Shipping Containers, Adhesives).

Each part of the 1946 Book has a complete subject index. There are two extensive tables of contents, the first listing all standards under general materials headings; the second, according to the serial designations of the standards.

A.G.A. IN NATIONAL EXPOSITIONS

The American Gas Association will sponsor combined gas exhibits in two national expositions to be held in the Fall of 1947, according to a recent announcement by Karl Emmerling, Chairman, Industrial and Commercial Gas Section.

The first will be a combined industrial gas exhibit at the National Metal Congress and Exposition in the National Amphitheatre, Chicago, October 18-24 where the latest in industrial gas equipment will be on display in the largest single exhibit of the Exposition. The "Blue Flame" motif will predominate, and an over all tie-in has been designed to promote gas fuel and reaffirm that "The Trend is to Gas for all Industrial Heating."

Three weeks later, November 10-14, the American Gas Association will sponsor a Combined Gas Cooking Exhibit at the National Hotel Exposition, Grand Central Palace, New York.

These two expositions will afford an opportunity for gas men, manufacturers and industrial and commercial gas consumers to meet and discuss their respective problems.

LEEDS & NORTHRUP REPRESENTATIVE IN SWEDEN TO ADDRESS SCIENTISTS

E. Burk Estabrook, who is connected with the sales department of Leeds & Northrup Company, has been invited to address Swedish engineering societies on "Automatic Temperature Control in Industrial Processes".

Mr. Estabrook was assigned by the company to make the journey at the invitation of The Royal Swedish Academy of Engineering Sciences and The Association of Swedish Technical Physicists, with which the Swedish Metallographers' Association and The Swedish Association of Mechanical Engineers are cooperating. Before returning to Philadelphia, Mr. Estabrook will visit various plants in Sweden, England and France.

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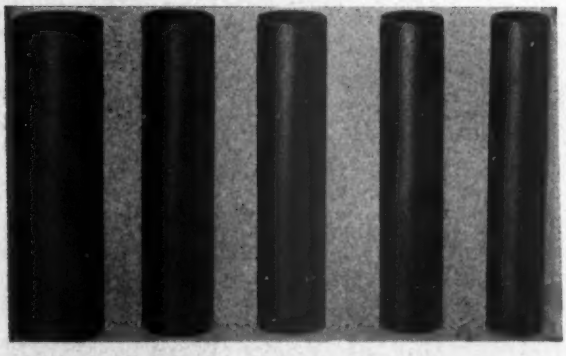

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GUNITE FOUNDRIES

ITALY'S GLASS INDUSTRY . . .

(*Continued from page* 356)

uct, Italian manufacturers say, is destined to revolutionize the glass making section devoted to domestic items of heat resistant and unbreakable opaque glass.

Prices of Italian glass products are much higher than before the war, due to the increased cost of essential materials and labor which averages more than 50 per cent. The increase in cost is especially true in regard to hand-made products. There are items that have increased more than 1,000 per cent over pre-war prices.

These increases, which are not in relation with the prices of glass makers in foreign countries, make it particularly difficult for the Italian industry to sell its products in certain foreign markets where there is direct competition with Czechoslovakia and Belgium.

Italian glass makers, however, are optimistic and are confidently looking forward to a busy future, both at home and abroad. They are setting the pace in Italy's industrial recovery.

DEPARTMENT OF COMMERCE EXHIBITS GLASSWARE

An exhibition of American handmade table glassware has been on display in the lobby of the Department of Commerce Building. It was arranged by the Office of Domestic Commerce, Department of Commerce, with the cooperation of the American Glassware Association.

Glass tableware of modern design was featured, including the display of 110 pieces comprised of goblets, vases, hurricane lamps, baskets and figurines.

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CORNING EXPANDS SOUTH AMERICAN PROGRAM

The fourth important development in Corning Glass Works' expansion program in South America, which began in 1943, has been completed with the purchase of a minority interest in Cristaleria Peldar S.A. of Colombia, it was recently announced.

The transaction is the first since the acquisition in 1945 of an interest in Cristalerias de Chile and is in accordance with Corning's policy of fostering cooperation and mutual confidence between South American glass industries and Corning Glass Works.

Cristaleria Peldar S.A. is located in Medellin and is at present engaged in the hand manufacture of bottles, tableware and novelties.

A.S.T.M. ELECTS OFFICERS

At its Fiftieth Annual Meeting, the American Society for Testing Materials elected T. A. Boyd, Head of the Fuel Department of General Motors Corp., as President of the Society; J. G. Morrow, Metallurgical Engineer of The Steel Company of Canada, Ltd., as Vice President; and, as Members of the Board of Directors, Truman S. Fuller, Engineer in Charge of Works Laboratory at General Electric Company; E. G. Ham, Technical Director, John A. Manning Paper Co., Inc.; James J. Laudig, Research Engineer, Delaware, Lackawanna and Western Railroad Co.; H. L. Maxwell, Supervisor of General Consultants, E. I. du Pont de Nemours & Co., Inc.; and L. J. Trostel, Manager of Research and Testing Laboratories, General Refractories Company.

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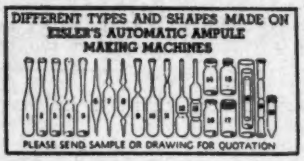
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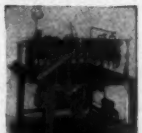

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